TO

MY STUDENTS

WHO HAVE GIVEN ME VALUABLE ASSISTANCE
IN THE SPIRIT OF FELLOW WORKERS
WITH WHOM MANY LESSONS HAVE BEEN LEARNED
AND
WITH WHOM MANY PLEASANT HOURS HAVE BEEN SPENT
BOTH INSIDE AND OUTSIDE THE CLASS ROOM
THIS BOOK IS DEDICATED

INTRODUCTION

When I was a boy in a country school a forward-looking teacher placed in the school a textbook entitled "Natural Philosophy."

This book was a storehouse of information. It described in simple language various kinds of natural phenomena. It was an introduction to the science of interesting everyday things. As a result of the study or reading of this book many of us began to understand in a new way the world about us.

It contained little mathematics. Such mathematical problems as it did present could be solved by arithmetic and were not so difficult as to detract from the interest of the book.

In the intervening years I have always regarded this book as most valuable. I have heard one of the most distinguished physicists in our American universities say that books of this kind did more to popularize science for the masses of the people than any similar books with which he was acquainted.

Since that time applied science has of course been greatly extended so that it touches our common lives at more points than formerly.

Mr. Daniel R. Hodgdon, a science teacher of experience, has prepared a book similar to the one I have briefly described, as a contribution to the field of general science as it exists to-day. It is simple, it has little mathematics, it is free from technicalities, it makes no pretense of being exhaustive, and it is, moreover, very interesting.

The kind of information that this book and similar books contain should be in the possession of all our young people. This kind of information causes them to understand the reason for many of the common facts in the world about them; it unconsciously

affords valuable mental discipline and unconsciously stimulates the imagination; it makes pupils more intelligent in the common objective phenomena of life and affords guidance in everyday affairs.

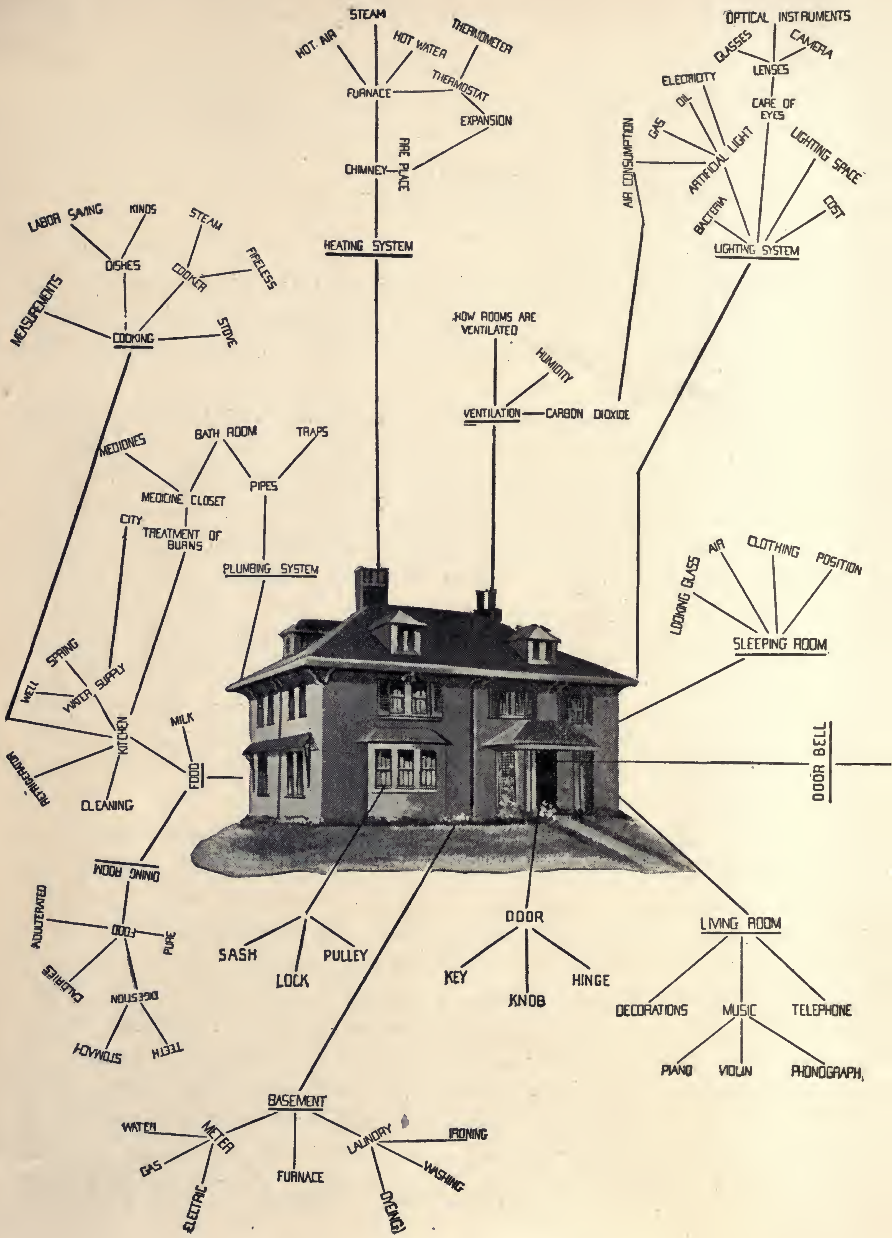
CALVIN N. KENDALL,
Commissioner of Education,
State of New Jersey

PREFACE

DURING the past few years there has been much discussion as to the best method for the teaching of Elementary General Science, the subject matter to be included, and the best arrangement of this subject matter.

After years of experience in teaching Elementary General Science from many outlines and through the use of many methods, the author has become firmly convinced that there is only one way in which the subject can be so taught as to mean much to the student. That Elementary General Science should prepare students merely for further pursuit of the various sciences included in this subject is an altogether narrow and unprogressive idea. The proper basis for the teaching of this subject is the environment of the student. From this point of view the textbook should so emphasize the fundamental facts and phenomena of nature that they are made of vital interest to the student and yet are at the same time scientifically presented, easily comprehended and useful both in the future study of science and in everyday life.

For several years the author has endeavored to discover through the use of tests and experiments what methods of presenting the subject best arrest the attention and hold the interest of the student. He has continually urged his classes to ask questions about everything they see of which they desire an explanation. By this method were gathered over one thousand questions differing much in type. Finding that most of the questions seemed to center about the home, the author one day drew on the blackboard a large diagram of a house. Each class has developed this diagrammatical outline from the questions asked, observations made and material nearest at hand. The use of the diagram led the author to see the desirability of using the home as the center around which the subject matter of



HEATING SYSTEM
FURNACE
STEAM
HOT AIR
HOT WATER
THERMOMETER
THERMOSTAT
EXPANSION
CHIMNEY
FIRE PLACE
OPTICAL INSTRUMENTS
GLASSES
CAMERA
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PIPES
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MEDICINES
TREATMENT OF BURNS
KITCHEN
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CITY
SPRING
WELL
REFRIGERATOR
CLEANING
FOOD
MILK
DINING ROOM
FOOD
ADULTERATED
PURE
CALORIES
DIGESTION
STOMACH
TEETH
SLEEPING ROOM
LOOKING GLASS
AIR
CLOTHING
POSITION
DOOR BELL
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LOCK
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DOOR
KEY
KNOB
HINGE
LIVING ROOM
DECORATIONS
MUSIC
TELEPHONE
PIANO
VIOLIN
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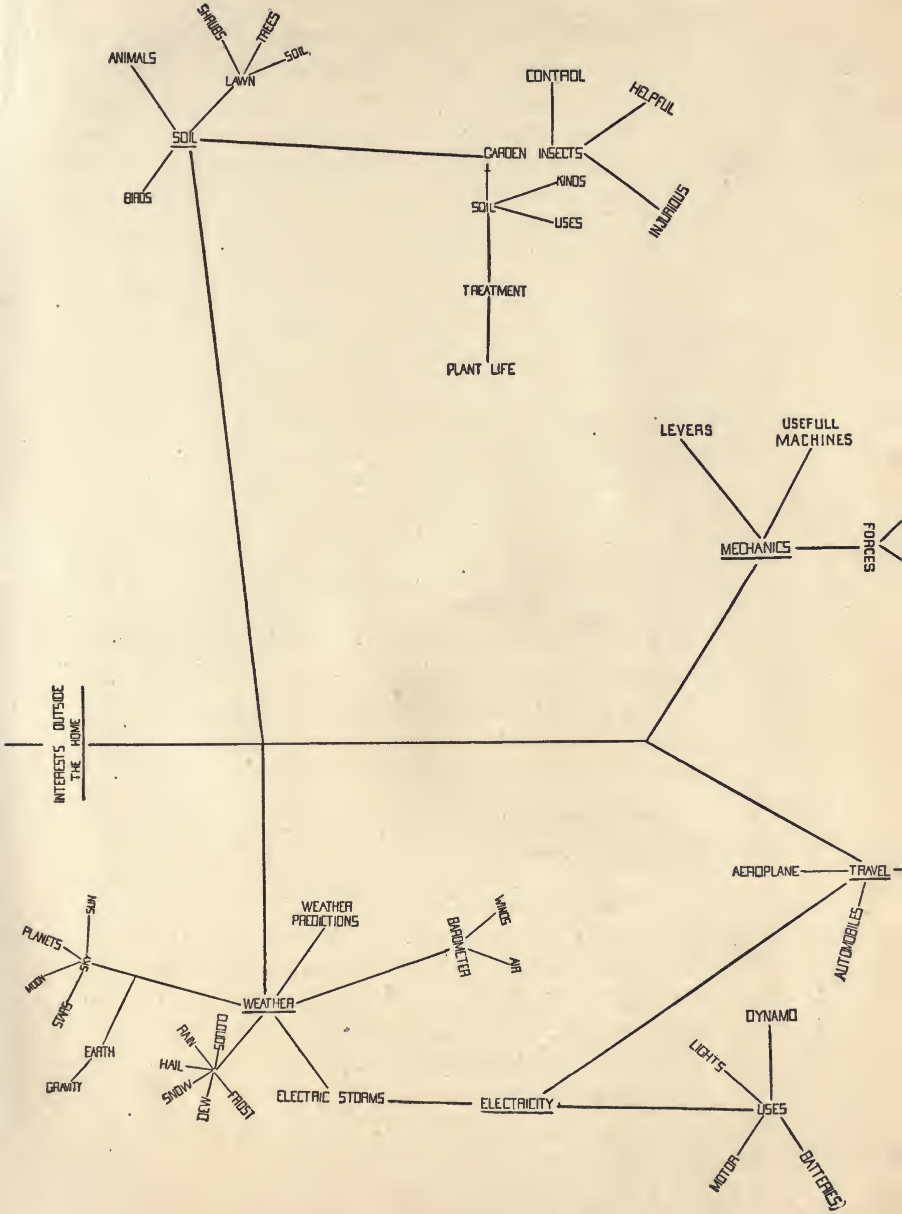
BASEMENT
METER
WATER
GAS
ELECTRIC
FURNACE
LAUNDRY
IRONING
WASHING
DYEING


INTERESTS OUTSIDE THE HOME
SOIL
ANIMALS
LAWN
SHRUBS
TREES
SOIL,
BIRDS
GARDEN
INSECTS
CONTROL
HELPFUL
INJURIOUS
SOIL
KINDS
USES
TREATMENT
PLANT LIFE
MECHANICS
LEVERS
USEFULL MACHINES
FORCES
TRAVEL
AEROPLANE
AUTOMOBILES
ELECTRICITY
USES
DYNAMO
LIGHTS
MOTOR
BATTERIES
ELECTRIC STORMS
WEATHER
WEATHER PREDICTIONS
BAROMETER
WINDS
AIR
SKY
SUN
PLANETS
MOON
STARS
EARTH
GRAVITY
CLOUDS
RAIN
HAIL
SNOW
DEW
FROST

the book could be built. With this idea as a basis it will readily be seen that a topic might be developed along physical, chemical, biological, geographical and other lines—a result which at once calls into play a great variety of facts and experiences which have, nevertheless, a common basis in the home. The author soon discovered that in progressing from one part of the house to another it was necessary that certain fundamental facts be discussed and digested before taking up others; that is, a certain logical progress of development must in all cases be maintained. Furthermore, it will be found that the sequence of chapters is such that the thought developed in each leads easily and logically into the subject of the following. For example, on page 323, Chapter IX, will be found a treatment of germs and disease which concludes with a discussion of germicides and a statement that light is the most powerful of all germicides. The following chapter takes up the subject of Light.

The teacher will find that some lessons have been planned to develop interest whereas others are essentially fact lessons. Also, he will find numerous questions based upon these two types. Moreover, the author has endeavored so to frame questions that they will develop free and informal discussion among the members of the class. In his classes students are given ten minutes of each period within which to bring in their observations regarding phenomena and to give explanations for such phenomena. It is a curious fact that from year to year many of the same observations and questions have been made and asked by different classes. A good plan is to let one student perform the experiment while the whole class enter into the discussion. Definite assignments to students who are especially interested in certain phases of the subject—such as the explanation of wireless apparatus, etc.—are always instructive and worth while provided a general discussion follows the report upon these assignments. The teacher will do well to encourage his students to start interesting discussions by their making statements somewhat after this manner: " This morning while coming to school I observed that smoke was sinking toward the ground. I do not know the reason for this but would like to have it explained," or a girl student might say, " Last evening while helping mother wash the dishes I noticed that two of the glasses stuck together. What

was the reason for this?" This method of socializing the recitation should prove a powerful stimulant for sharpening the student's powers of observation. If, after these lessons have been pursued for a few weeks, the students begin to tell the teacher that they are enjoying the course in science more than almost any other of their courses, he should not be surprised, for has not a great portion of the course been drawn from the students' actual experiences of everyday life?

That students have graduated from school with very little knowledge of the interesting facts of their environment, all too little ability to understand the simple phenomena of nature, and little if any desire to examine into the causes of these phenomena, is a regrettable fact. If the course in Elementary General Science which has found such universal favor in the first year of our high-school course shall serve to introduce the pupil to a better understanding of the simple facts and fundamental principles of natural laws, and shall also be successful in cultivating in the pupil a desire to know more about his environment, this course will have found a very definite place for itself in the curriculum of the public school.

DANIEL R. HODGDON.

NEWARK, NEW JERSEY,
February 1st, 1918.

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The author wishes to give recognition to the following members of the faculty and student body of the State Normal School, Newark, N. J.: to Miss Grace Engels, teacher, who drew Figure 49A; to Miss F. M. Egnor who drew Figure 142; to Miss Anna Balling, who has often given the author much valuable assistance; to Miss Sophie

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The author desires to mention Mr. Fred Beals, a true friend and valued co-worker who died two years before work upon this book was begun. At the time of his death Mr. Beals was working with the author upon the outline of an Elementary Physics. Because Mr. Beals was greatly interested in the subject of General Science the author regrets that he was deprived of the sympathetic co-operation of one whose assistance and valuable criticism in the preparation of this book would have been of inestimable value.

The author wishes to acknowledge the many courtesies of the following, who have very kindly furnished cuts:

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GENERAL SCIENCE

CHAPTER I

ATMOSPHERIC MOISTURE AND EVAPORATION

EVAPORATION

How Moisture Gets into the Atmosphere.—Wet thoroughly with water a piece of cheesecloth about two feet square and hang the cloth on a T-shaped stick about three feet long. Balance the stick on a prism or cylindrical object, such as a piece of crayon or pencil.

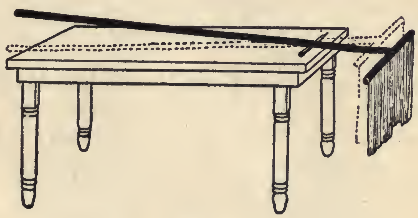


Fig. 1.

Why is it necessary to rebalance the stick after a minute?

Where does the water go?

Why can we not see water which has passed off into the air?

Evaporation is the chief method of supplying the atmosphere with moisture. A liquid is said to evaporate when it changes into an invisible gas and is absorbed by the atmosphere. If a wet cloth freezes, it will dry on the line as the ice evaporates. That is, the ice will change from a solid directly into a vapor. This process is called **sublimation.**

Water evaporates more rapidly in some places than in others. It is estimated that in the course of a year a body of water in Mississippi would be lowered fifty inches by evaporation; in New

York only about forty inches; at Denver seventy inches; at Lake Superior twenty inches; and in southern Arizona about one hundred inches.

Water will not evaporate so quickly on some days as on others. Though few can give the reason, we all know, from experience, that there are "good" and "bad" days for drying clothes. We are all aware of the fact. Some days the light wind steals the moisture from the clothes with delightful rapidity; another time they hang for hours without effect, for the air is so full of vapor that it can receive no more, and the "drying" process is at a standstill.

A sponge or flannel cloth, or even a piece of sugar, will serve as a good example. If any one of these is held over a basin of water so that it just touches, it will soak up water until it can hold no more. The air does the same, but receives the vapor instead of soaking it up. In the examples given, the water is drawn up by capillary attraction. A sponge or cloth or piece of sugar can always take up a certain quantity of water and no more, and always the same amount. Not so with the air. The amount of moisture that the air can take up depends upon its temperature. Warm air holds more moisture than cold air.

To Show that Warm Air Holds More Moisture than Cold Air.—Take a large flask, and put into it just enough water to make a thin film on the inside of the flask when shaken. Now warm the flask gently, never bringing its temperature to the boiling point. When the water disappears from the inside, tightly cork the flask and allow it to cool.

Notice that when the flask is hot no moisture can be seen. After the flask is corked no moisture can enter; but as soon as the flask cools the moisture is seen collecting on the inside of the flask. As long as the air in the flask is hot it can hold a large amount of moisture, but when the air cools it can not hold as much moisture.

Effects of Wind on Evaporation.—We find also that clothes dry or mud puddles dry up more quickly on a windy day than on a day when there is little wind. When the air around a wet object is full of water, the object is unable to give up any more of its moisture to the atmosphere, but when the air which is saturated

with moisture moves aside to let air containing less moisture take its place, more of the water on the wet object is evaporated.

Other Ways in which Moisture Gets into the Atmosphere.—All animals breathe out water vapor into the atmosphere. A person will give off to the atmosphere each day, by perspiration and respiration, from a pint to three quarts of water, according to the amount of exercise taken. Plants give out large quantities of water. A sunflower will give off from a pint to a quart of water each day, or about 125 pounds of water during the season.

An average oak tree gives off about 200 gallons of water in a day during the summer. A birch tree with about 200,000 leaves has been estimated to give off from 700 to 900 pounds of water, or about 125 gallons, on a hot day in summer, and only about two or three gallons on a cool day. In hot weather an acre of grass will give off enough water to the atmosphere to equal its own weight, or about 1600 gallons a day. This would mean about six and a half tons of water or a little more than 50 barrels. An average sized city lot covered with grass will give to the atmosphere about 10 barrels of water on a hot day. This means that if our lawns are well kept they will give off water vapor in large quantities.

Evaporation from the Soil.—Large amounts of water evaporate from the soil, but the amount depends upon the condition and kind of soil. More water evaporates from soil which is full of tiny openings (fine porous soil) since the water rises to the surface more rapidly in such soil than in soil which is very loosely packed together.

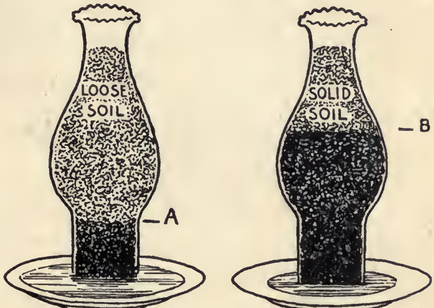


FIG. 2.

A farmer cultivates his garden frequently during warm weather in order to form a dust mulch an inch or so thick. The water will rise in the soil up to the dry layer, and the greater part of the water will be absorbed by the roots of the plant. This process is called "dry farming." Rolling

a field or lawn checks evaporation since the soil is so closely packed together it is no longer porous, hence, allowing no place for the water to rise between the dirt particles.

In order to show that water does not rise as quickly through very loose fine soil, fill two lamp chimneys with soil. Place at the top of one chimney about two inches of fine, dry, loose soil and in the other chimney pack the soil closely together. Place both chimneys in a basin of water.

Questions

1. What do people mean when they say that clothes on the line "freeze dry"?

2. Why will water evaporate from a lake in Arizona more quickly than in New York?

3. What is wrong with the idea that heat dries up water?

4. Why do clothes dry better on a warm day than on a cold day; on a dry than on a damp day; on a windy day than on a still day?

5. Why are forests important to the rainfall of a country?

6. Give a good argument for the conservation of the forests.

7. What effects do the trees and the well-kept parks in a city have on the atmosphere?

8. How much moisture, on an average, do the students of your school give off to the atmosphere during the day?

9. In setting out plants, why should we take care to pack the soil nicely around the roots, but to leave the soil loosely packed about an inch from the surface?

10. Why does a farmer cultivate his garden shortly after a shower?

11. Why are fruits and vegetables spread out in thin layers while drying? What is dehydration?

12. Why are pans for evaporating water from sugar and salt large and shallow?

EFFECTS OF EVAPORATION

Experiments to Show the Effects of Evaporation.—Arrange in a vertical position two thermometers with similar scales. Attach to one of the thermometer bulbs a piece of cheesecloth or wick. Allow the cloth to extend into a small bottle of water. The thermometer to which the cloth has been fastened is called the wet thermometer because water is rising in the cloth and evaporating

from the bulb. The other thermometer is called the dry thermometer. Find out how many degrees cooler the wet thermometer is than the dry thermometer. Show how this experiment proves that heat is absorbed when water evaporates.

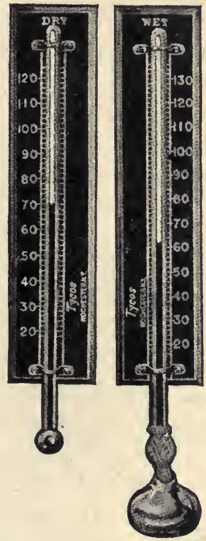


FIG. 3.—Why does the wet thermometer read less than the dry?

If we wet one hand in warm water and let the other hand remain dry, we shall soon realize the effect of moisture evaporation from the body. Although we may come from a warm bath, we soon feel cold unless the water is removed from the body almost immediately —before it has time to evaporate. If the evaporation is slow, not so much heat is absorbed in evaporation at any one time, but if the evaporation is rapid, a great deal of heat is absorbed.

This may be easily shown by placing a small amount of ether in a watch glass and placing the watch glass on a drop of water on a cork. A thin film of water will form on the under side of the glass. Blow through a piece of glass tubing directly on the ether.

Why will blowing on the ether make it evaporate more quickly?

Why does the thin film of water turn into ice and freeze the watch glass to the cork?

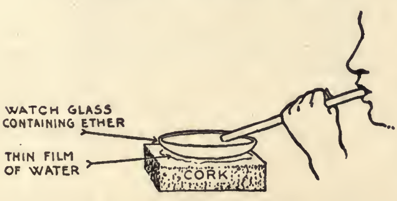


FIG. 4.

Why would not the thin film of water turn to ice if the ether were allowed to evaporate slowly?

Manufacture of Ice. — This principle of evaporation is used commercially for the manufacture of ice. Liquid ammonia, when evaporating, consumes large quantities of heat. This does not mean aqua ammonia, such as we buy at the drug store, which is common water with a large amount of ammonia gas absorbed. If this gas is put under great pressure, it will change to a liquid.

The ice manufacturing plants have a compressor, *B*, Fig. 5, and cooling coils, *C*, over which cold water is running, since gaseous ammonia changing into a liquid gives off large quantities of heat. Every person is familiar with the compressing of air with a pump to fill bicycle tires or automobile tires. We know air gets very warm as it is compressed; so does the ammonia. The liquid ammonia, after it has been cooled by the water, is allowed to run through pipes which are surrounded with brine. In this brine are cans of water, *G*. The ammonia liquid, when entering the

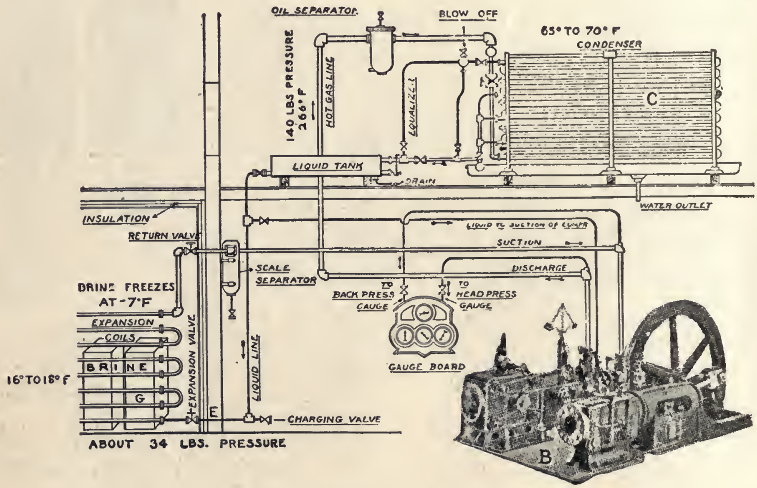


Fig. 5.

pipes at *E*, changes by evaporation from a liquid to a gas, but in order to change into a gas it requires a large amount of heat. This heat is removed from the brine, which in turn removes heat enough from the water to freeze it.

Fig. 6 shows a refrigerator for home use. Instead of ammonia gas, sulphur dioxide gas is used.

What is the motor *A* used for?

Why is the compressor *B* necessary?

Why are the coils at *C* called the cooling coils?

Why are the coils in the ice chamber called the refrigerating coils?

What must be done to the liquid sulphur dioxide in order to cool the ice box?

What must be done to the gas in the refrigerating coils before it can be used again?

Iceless Coolers.—The principle of evaporation, used in keeping food and water cool by the natives of tropical countries, is used to-day

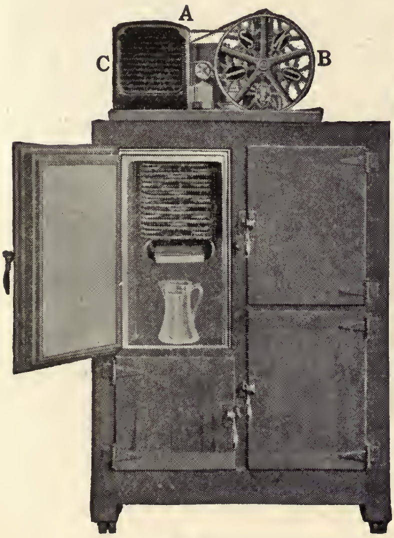


FIG. 6.

FIG. 7.

by people of every country by making a container of porous material which is dipped in water for a few moments every day or two. The water evaporates from the material if the container is placed where there is a good circulation of air, maintaining a low degree of temperature, even as low as some of the average ice boxes. Fig. 7.

Inexpensive Iceless Refrigerators.—In some parts of the country refrigerators are made by covering a frame of wood with burlap,

Canton flannel, or duck. Of these materials duck is by far the best. A number of flannel wicks are sewed to the covering material and the other ends of the wicks allowed to rest in a pan of water on the top of the frame. Shelves are built into the frame for holding food supplies. The water soaks into the covering through the wicks from the pan. As the water evaporates, large quantities of heat are removed, keeping the temperature inside the refrigerator sometimes as low as 50° F.

Relation of Evaporation to Life.—So powerfully cooling is perspiration that this process is Nature's first relief in the protection of the body from high temperature. As the surrounding temperature rises, the amount of perspiration increases, and the body is able to maintain, for a time, its normal standard of health at an incredibly high degree of heat. Strong, perfectly healthy men have been able to remain for some time in rooms whose temperature was as high as 48 degrees above the boiling point of water (212° F.), without any marked rise of bodily temperature. Nor was there any severe discomfort, the temperature of the body being kept down solely by the evaporation of perspiration from the skin. But it must be remembered that, to make this means of cooling possible, it is absolutely essential that the air be dry, and capable of taking up moisture.

The body generates large quantities of heat during the process of changing food into substances that it can use. Much of this heat must be removed. Moisture comes out of our pores and evaporates from the body. If the moisture did not evaporate there would be no cooling process. If we are very hot, we fan ourselves, because the air around our faces is so full of moisture that it cannot absorb the perspiration. The fan, like the wind, causes drier air to come in contact with our faces and absorbs the drops of perspiration.

If anything prevents the evaporation of moisture from the body, it stores up large quantities of heat and the temperature rises. If a person does not get relief before the temperature reaches 106° or above, death will soon follow. The doctor tries to cool the body by evaporation. If he is not able to get perspiration started, he gives the patient an ice bath. This, of course, removes

much of the heat but drives the blood from the surface. The patient is then removed from the ice bath and placed in hot blankets. The sudden change stimulates the sweat glands, and perspiration starts, followed by evaporation.

Nature has provided us with a well balanced regulator to control the body, a regulator known to us as the **nervous system.** By this regulator, as the body becomes overheated, more blood is brought up to the skin in order that the extra heat may pass off into the outside air. When the body feels cold, this regulator causes the little channels in which the blood circulates to contract, so that much less warm fluid can stream through them. The blood is then driven to the deeper parts of the body, where the heat necessary to life can be maintained.

This same regulator causes the pores of the skin to pour out perspiration on its surface when the body becomes very hot. This sweat cools the body by evaporation.

The range of health is confined between 97½° and 99½° Fahrenheit of bodily temperature. A bodily temperature below 97½° F. portends death by evaporation or by a discontinuance of the heat-producing process within the body. A temperature above 99½° F. portends death by an excess of heat not removed by evaporation.

Sunstrokes, fevers, and colds are conditions due to failure of the pores of the body to act normally. A person will often take a hot bath and drink hot lemonade to bring out perspiration which when evaporating will relieve the body of great quantities of heat.

Why We Feel Chilly after Coming Out of a Crowded Theater.—When there are a great many people in a room, an excess of moisture results from perspiration and respiration. The air can no longer take away the moisture from the body. A person leaving such a room for the drier outside air gives up the moisture which has collected on the body. This takes away a great deal of heat, and thus often causes a chill.

Wearing of Clothes.—The wearing of loose, porous clothing allows perspiration to take place normally. People should wear medium-weight underclothing throughout winter seasons. If heavy underclothing is worn and the person spends most of the day in an office, schoolroom, or house where the temperature is equal

to summer heat, large quantities of moisture will collect on the body, as evaporation does not take place freely. Very heavy wraps and fur coats should be worn only during unusual exposure, as in driving or motoring.

Questions on Effects of Evaporation

1. Why does sprinkling the lawns and streets on a hot day in summer cool the surrounding atmosphere?
2. Why is it so much cooler after a thunder shower?
3. Why do we feel cold in a draft?
4. The air is just as warm when we are riding in an automobile as it is when we are standing on the lawn. Why do we feel much cooler riding?
5. Why does not the tennis player feel the heat as keenly while he is playing as when he sits down?
6. In warm regions large, porous earthen vessels, called "ollas" (o-ya), are placed outdoors. The outer surface is constantly covered with a film of water. Why is the water kept cool?
7. Why should we be careful to see that all our clothes are dry and "aired" before putting them on?
8. Why do we feel chilly when we come out of the water and stand on the shore after we have been in bathing?
9. Why does bathing the forehead with alcohol cool the head?
10. Which will be cooler, a glass of water or a bottle of water standing on the table? Why?
11. Why should extra wraps be provided for a person who has been in a crowded hall?
12. Why should a person take a cold shower after a warm bath in the morning during the winter?
13. Why will a hot bath in summer keep a person cooler longer than a cold bath?
14. Why do people place a wet cloth over butter jars in summer?
15. Why do we catch cold if we get our feet wet?
16. Why do we get cold if we sit in a draft?
17. Why did the little boy die who had his body painted with gold paint to represent an angel?
18. Why is a hunter able to tell which way the wind is blowing by

wetting his finger at his mouth and holding it high above his head?

19. Would the man who kept a wet cloth over his gas meter be able to get more gas for his money?

20. Why is a healthy dog's nose always cold?

MOISTURE IN THE ATMOSPHERE

Value of Moisture in the Atmosphere.—Water vapor is hidden away in many of the secret recesses of our wonderful air ocean. If moisture could be taken away from us, not only would all green things wither for lack of it, but the sun would shine down upon us with a fierceness beyond conception, for the floating mists, clouds, or other moisture in the air keep these burning rays from us. They act in another way also. Their presence keeps a great quantity of the sun's light from us. Acting as a screen, not only do they steal heat from the traveling sunbeams, but they diffuse the sunlight.

Again, the " night work " of moisture is very important. During the day the earth gathers heat from the sun's rays as they beat downward. When the sun " sets," the stored up heat begins to release itself into space. The vapor in the air prevents this heat from radiating too rapidly. If it were not for this blanket of moisture to check the heat, the suddenness of the chill would be terrible.

Cloudy nights are warmer than clear nights, for the clouds act as a blanket, sending back to the earth the heat which is radiated. On clear nights the earth loses its heat much more rapidly, for the light veil of vapor in the air does not arrest the warmth from the earth as well as heavy clouds do.

Relation of Evaporation to our Bodily Comfort.—In deserts, where the relative humidity is small, evaporation goes on very rapidly. Wherever there is a large amount of moisture on surfaces, the relative humidity is great and only a little evaporation can take place. Such conditions may be found in forests of the tropical countries. The same conditions apply to temperate zones in the United States and Europe where there is a small amount of rainfall in summer time. This lack of evaporation affects our comfort, because some days are humid, close, or muggy. At such times the heat becomes very oppressive. We perspire easily and are

very uncomfortable because little evaporation can take place from the surface of the body when the air is humid.

On clear, dry days we feel more comfortable because evaporation from the skin removes the perspiration, the percentage of relative humidity being so low that the air can rapidly evaporate great quantities of water vapor. It is because of this that the temperature of 90° to 100° or more in Arizona is not accompanied by such uncomfortable conditions as we experience under equal temperatures in the Mississippi Valley or near the Atlantic Coast where the relative humidity is greater.

Humidity.—To most of us "humidity" is a very indefinite term. We know that when the humidity is high there is much moisture in the air; when it is low there is little moisture in the air, but the significance and importance of all this is very hazy in our minds. Few persons take note of "humidity" at all, particularly as an element of conditions which affect their health. They realize that "muggy weather," especially in summer, is depressing and uncomfortable, but they do not know why "humidity" so affects them. Yet humidity is of the utmost importance in the consideration of healthful temperatures for the home and elsewhere. The lack of humidity, or moisture, causes much discomfort, ill health, catarrh, colds, and other diseases of the mucous membrane. If we had the proper percentage of humidity in our homes in winter, we should not only be more healthy and comfortable, but we should also save from $12\frac{1}{2}\%$ to 25% of our total cost of heating.

Health authorities state that in the average home, heated by steam or hot water to a temperature of 72° F., the relative humidity averages but 28%, while with hot air furnaces it is as low as 24%. In the great desert wastes the humidity averages 30%. Now, if a person passes from this dry "indoor climate" into the outdoor air, the percentage of humidity in which may be 70% or more, the violent change seriously affects the air passages and mucous membrane. This causes bronchitis, pneumonia, and kindred ills. The importance of determining and regulating the humidity of the home, school, office, factory, or wherever people congregate

Humidity is just as variable as temperature because of the evaporation of water in the air; the dews, the rains, the winds depend entirely upon fluctuations of the heat in the air. The percentage of humidity may be anywhere up to 100%, a figure which indicates **saturation** of the air with vapor.

How Humidity is Measured.—There are two ways of expressing humidity. The actual amount of water vapor in the atmosphere is known as the **absolute humidity.** Absolute humidity is expressed in grams of water vapor per cubic foot of air.

The air in a schoolroom 20 feet wide by 30 feet long by 15 feet high would hold at 70° Fahrenheit 10.4 pounds of water vapor, if the air were saturated.

The **relative humidity** is measured in per cent. Air saturated would have 100%, and perfectly dry air would have a relative humidity of 0%.

FIG. 8.—Hair Hygrometer.

Relation of Humidity to Bodily Heat.—Humidity influences the heat of our bodies in two ways. First, moist air conducts heat from the skin more readily than dry air. In warm weather the difference in temperature between the body and the air is so slight that neither moist nor dry air conducts any large amount of heat from the surface, but when the difference of temperature is greater, the effect of humidity in the conduction of heat is very marked. Moist air at 65° F. is chilly to one sitting still, while dry air at this temperature is very comfortable. When perspiration becomes necessary to maintain the normal temperature of the body, the moisture of the air interferes with the escape of heat from the body, for evaporation of the perspiration does not take place rapidly in moist air. Therefore, a high percentage of humidity makes us feel warmer on a warm day and cooler on a cool day because in the former case it interferes with the evaporation of the perspiration from the body, while in the latter instance the heat is conveyed more rapidly from the body, causing a sense of coolness.

The following table of tests, made to determine the exact bod-

ily sensations which different relative degrees of temperature and humidity cause, is interesting and instructive. Families, schools, factories, and public institutions will find it a valuable guide for the regulating of humidity.

75% Relative Humidity

TEMPERATURE	BODILY FEELING
55° F	Very cold
65° F	Chilly
75° F	Comfortable
85° F	Too Warm
95° F	Very Hot

50% Relative Humidity

35° F	Very cold
50° F	Chilly
65° F	Comfortable
75° F	Warm
85° F	Too Warm
95° F	Very hot

30% Relative Humidity

55° F	Very cold
65° F	Chilly
75° F	Comfortable
85° F	Warm
95° F	Too warm
105° F	Very hot

The ordinary form of hygrometer, an instrument for measuring the relative humidity of the atmosphere, may be easily constructed.

Construction of Hygrometer.—Two thermometers are mounted on a board about four inches apart, one of which is exposed to the free air, the other having its mercury bulb covered with a few strands of loosely twisted lamp wick or silk which extend down

into the water reservoir. The reservoir may be made of any wide-mouthed bottle.

The difference between the readings of the wet and the dry thermometer should not be more than 10 degrees or less than 7 degrees. The temperature of the room should be between 65° and 68° F. If we do not feel comfortable, more vapor is needed in the atmosphere.

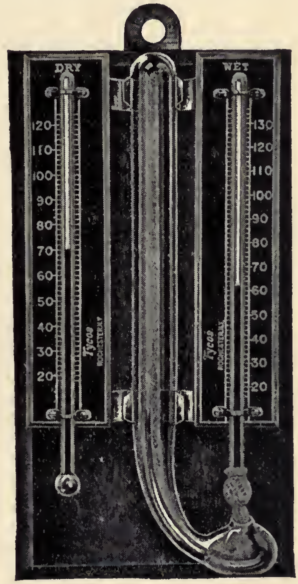


Fig. 9.—Wet and Dry Bulb.

Hygrometer Paper.—Some hygrometers owe their hygroscopic properties to chemicals which change their color with the percentage of humidity of the air. The following chemicals may be used to color flowers, light muslin, or paper.

1. Cobalt chlorine, 1 part; gelatine, 10 parts; water, 100 parts. The normal coloring is pink; this color changes into violet in medium humid weather, and into blue in very dry weather.

2. Cupric chloride, 1 part; gelatine, 10 parts; water, 100 parts. The color is yellow in dry weather.

3. Cobalt chloride, 1 part; gelatine, 20 parts; nickel oxide, 75 parts; cupric chloride, 25 parts; water, 200 parts. The color is green in dry weather.

Hygroscopes.—Wood, quill, hair, whalebone, animal membranes, whip-cord, cat gut, wild oats, common feathers, and grass are known as hygroscopes, since they are very sensitive to changes in moisture.

Attempts have been made to produce a hygrometer to take the place of the wet and dry bulb instruments; but they have failed because of the great inaccuracy caused by temperature and dust. A good hygrometer has been constructed to read within five per cent error. Such hygrometers are often used in cigar cases. The "old man and old woman weather prophets" in a little house is an example of a hair hygrometer.

The following table will assist the class in determining the relative humidity of the room from the hygrometer.

RELATIVE HUMIDITY TABLES

Per Cent Fahrenheit Temperatures

Difference in Degrees between Wet and Dry Bulb Thermometers

Reading of Dry Bulb Thermometer.	1.0	2.0	3.0	4.0	5.0	6.0	7.0	8.0	9.0	10.0	11.0	12.0	13.0	14.0	15.0	16.0	17.0
	Percentage of Relative Humidity.																
32	90	79	69	60	50	41	31	22	13	4							
33	90	80	71	61	52	42	33	24	16	7							
34	90	81	72	62	53	44	35	27	18	9	1						
35	91	82	73	64	55	46	37	29	20	12	4						
36	91	82	73	65	56	48	39	31	23	14	6						
37	91	83	74	66	58	49	41	33	25	17	9	1					
38	91	83	75	67	59	51	43	35	27	19	12	4					
39	92	84	76	68	60	52	44	37	29	21	14	7					
40	92	84	76	68	61	53	46	38	31	23	16	9	2				
41	92	84	77	69	62	54	47	40	33	26	18	11	5				
42	92	85	77	70	62	55	48	41	34	28	21	14	7				
43	92	85	78	70	63	56	49	43	36	29	23	16	9	3			
44	93	85	78	71	64	57	51	44	37	31	24	18	12	5			
45	93	86	79	71	65	58	52	45	39	33	26	20	14	8	2		
46	93	86	79	72	65	59	53	46	40	34	28	22	16	10	4		
47	93	86	79	73	66	60	54	47	41	35	29	23	17	12	6	1	
48	93	87	80	73	67	60	54	48	42	36	31	25	19	14	8	3	
49	93	87	80	74	67	61	55	49	43	37	32	26	21	15	10	5	
50	93	87	81	74	68	62	56	50	44	39	33	28	22	17	12	7	2
51	94	87	81	75	69	63	57	51	45	40	35	29	24	19	14	9	4
52	94	88	81	75	69	63	58	52	46	41	36	30	25	20	15	10	6
53	94	88	82	75	70	64	58	53	47	42	37	32	27	22	17	12	7
54	94	88	82	76	70	65	59	54	48	43	38	33	28	23	18	14	9
55	94	88	82	76	71	65	60	55	49	44	39	34	29	25	20	15	11
56	94	88	82	77	71	66	61	55	50	45	40	35	31	26	21	17	12
57	94	88	83	77	72	66	61	56	51	46	41	36	32	27	23	18	14
58	94	89	83	77	72	67	62	57	52	47	42	38	33	28	24	20	15
59	94	89	83	78	73	68	63	58	53	48	43	39	34	30	25	21	17

RELATIVE HUMIDITY TABLES—*Continued*

Reading of Dry Bulb Thermometer.	1.0	2.0	3.0	4.0	5.0	6.0	7.0	8.0	9.0	10.0	11.0	12.0	13.0	14.0	15.0	16.0	17.0
	Percentage of Relative Humidity.																
60	94	89	84	78	73	68	63	58	53	49	44	40	35	31	27	22	18
61	94	89	84	79	74	68	64	59	54	50	45	40	36	32	28	24	20
62	94	89	84	79	74	69	64	60	55	50	46	41	37	33	29	25	21
63	95	90	84	79	74	70	65	60	56	51	47	42	38	34	30	26	22
64	95	90	85	79	75	70	66	61	56	52	48	43	39	35	31	27	23
65	95	90	85	80	75	70	66	62	57	53	48	44	40	36	32	28	25
66	95	90	85	80	76	71	66	62	58	53	49	45	41	37	33	29	26
67	95	90	85	80	76	71	67	62	58	54	50	46	42	38	34	30	27
68	95	90	85	81	76	72	67	63	59	55	51	47	43	39	35	31	28
69	95	90	86	81	77	72	68	64	59	55	51	47	44	40	36	32	29
70	95	90	86	81	77	72	68	64	60	56	52	48	44	40	37	33	30
71	95	90	86	82	77	73	69	64	60	56	53	49	45	41	38	34	31
72	95	91	86	82	78	73	69	65	61	57	53	49	46	42	39	35	32
73	95	91	86	82	78	73	69	65	61	58	54	50	46	43	40	36	33
74	95	91	86	82	78	74	70	66	62	58	54	51	47	44	40	37	34
75	96	91	87	82	78	74	70	66	63	59	55	51	48	44	41	38	34
76	96	91	87	83	78	74	70	67	63	59	55	52	48	45	42	38	35
77	96	91	87	83	79	75	71	67	63	60	56	52	49	46	42	39	36
78	96	91	87	83	79	75	71	67	64	60	57	53	50	46	43	40	37
79	96	91	87	83	79	75	71	68	64	60	57	54	50	47	44	41	37
80	96	91	87	83	79	76	72	68	64	61	57	54	51	47	44	41	38
82	96	92	88	84	80	76	72	69	65	62	58	55	52	49	46	43	40
84	96	92	88	84	80	77	73	70	66	63	59	56	53	50	47	44	41
86	96	92	88	85	81	77	74	70	67	63	60	57	54	51	48	45	42
88	96	92	88	85	81	78	74	71	67	64	61	58	55	52	49	46	43
90	96	92	89	85	81	78	75	71	68	65	62	59	56	53	50	47	44
92	96	92	89	85	82	78	75	72	69	65	62	59	57	54	51	48	45
94	96	93	89	86	82	79	75	72	69	66	63	60	57	54	52	49	46
96	96	93	89	86	82	79	76	73	70	67	64	61	58	55	53	50	47
98	96	93	89	86	83	79	76	73	70	67	64	61	59	56	53	51	48
100	96	93	90	86	83	80	77	74	71	68	65	62	59	57	54	52	49

Schoolroom "Deserts."—A usual cause for nervousness, or "fidgets," among school children is the dried-out, desert-like atmosphere of the school room, the temperature of which, during the winter months, is usually above 72° F. The introduction of vapor into the room, through the placing of pans of water, wet cloths over the radiators, opening of the steam valves, or throwing open

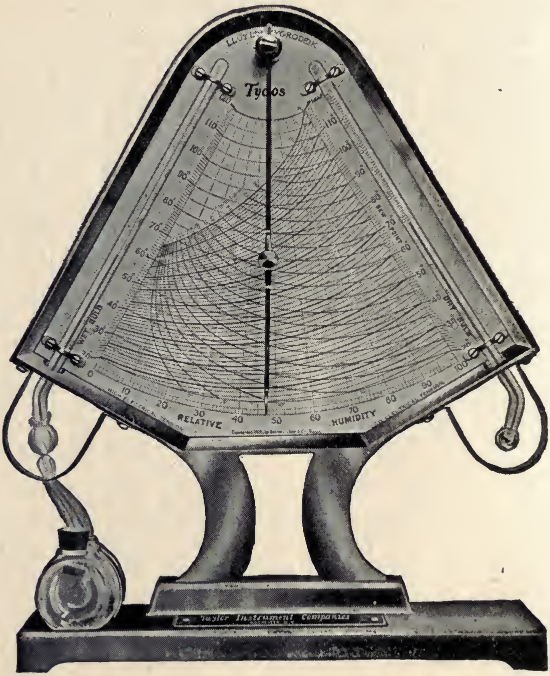


Fig. 10. A Hydrodeik.

the windows when possible, will almost instantly relieve the tension of a schoolroom full of children. On the "perfect days" in May and early June, with all windows open, admitting freely the outdoor air, it is interesting to note that the thermometer stands at about 65° to 68° F., and the hygrometer registers about 60% relative humidity.

Vertical wicks of felt with their lower ends in water kept hot

by the heating apparatus rapidly yield a supply of moisture. Evaporation is greatly facilitated by placing the water or wicks in the current of heated air entering the room. By a suitable construction, the water may be replenished automatically. In very cold, dry weather the air supply of an ordinary medium-sized house requires the addition of not less than ten gallons of moisture every twenty-four hours, and sometimes much more.

How We Take Cold.—Constant colds and sore throats testify to the effects on the skin and mucous membrane of too high a temperature and too dry an air. Anæmia, debility, and irritability bear witness to the ill effect of this form of heat on the blood and nerves. Too often the occupants of overheated houses think this is the way to be comfortable.

The prime cause of colds or chills is not exposure to cold, but to the overheated, confined air of rooms, factories, and public meeting places. Colds and sore throats are the results, not of cold air, but of infection. If the mucous membrane is healthy, the lining of the nose and throat is pale pink, stretches taut over the surface it covers, and protects from infection. Ill-ventilated street cars as well as poorly ventilated, dry houses often may be blamed for many of our colds.

A steady supply of pure air should be admitted at all times to every occupied room. A piece of board about 8 inches wide and long enough to fit on the bottom sash of a window, in each room, will allow air to enter and rise toward the ceiling if the window is open a little way at the bottom. The air coming in from outdoors will gradually descend on the occupants, who will thus feel no draft. Contact with fresh, cold air does not cause chills or colds. It stimulates activity of both the mind and the body. Careful experiments have shown that for each degree above 65° the power of mental concentration diminishes. This fact is important for those who are working in offices, factories, shops, and schools.

Questions

1. Why does the air feel so chilly in the spring when snow and ice are melting?

2. What would be the difference between the bodily feeling on

a day with the humidity 93% and temperature 80° F., and that on a day with the humidity 65% and the temperature 80° F.?

3. Why should we put wraps on when leaving the house on a cold day?

4. Why does the furniture come apart in a room where there is little humidity?

5. Why are plants beneficial to a room?

6. Why does the atmosphere in New York City feel colder at 10° F. than the atmosphere in Montana at 0° F.?

7. Why is it necessary to heat a house above 68° F. when the relative humidity is only 30%?

8. If a room were very damp, why would it be necessary to heat it above normal temperature before the occupant would feel comfortable?

CHAPTER II

MOISTURE COMING FROM THE ATMOSPHERE

WATER CONDENSING NEAR THE EARTH

Dew.—Put a few pieces of ice in a shiny can half full of water. If there is sufficient moisture in the air of the room, or a relative humidity of about 60 per cent, fine drops of water begin to form on the can, slowly increasing in size until large drops of dew appear. The temperature of the can when the dew begins to form is called **dew point.** This means that dew would collect on all the objects in the room if they were cooled to the temperature produced by placing ice in the can.

We have learned that clothes dry better on a warm day because warm air holds more moisture than cold air. As soon as the air of the room comes in contact with the cold can, it is cooled and must drop some of its moisture, since the cold air can not hold as much water vapor as warm air.

Dew on the Grass.—During the night the ground is cooled by radiation. The air next to the ground is chilled by coming in contact with the cold ground. If this air has a great deal of water vapor in it, moisture will be deposited on the grass just as the water was deposited on the can.

Dew forms on the grass more quickly than on the wooden sidewalk because the grass cools off faster than the wood. Some things give up heat very quickly, while others hold it for a long time.

Frost.—Frost is not often frozen dew. Usually it is frozen water vapor. The temperature of the cold object on which dew would form is below 32° F., which means that the frozen vapor is deposited directly on plants before it can form into dew. Frost is deposited in many fantastic crystal forms on our windows.

Things to Remember about Dew and Frost.—No dew forms during cloudy nights; therefore clouds will prevent frost, because they act as a blanket, keeping the heat of the earth in.

Neither dew nor frost will form on windy nights since the wind does not give the air time to cool and drop its moisture near the earth.

Dew will form on clear nights, and, if the night is cold, frost is sure to form, since the heat of the earth escapes quickly. Very little dew will form on the tops of trees, but a great deal will form on

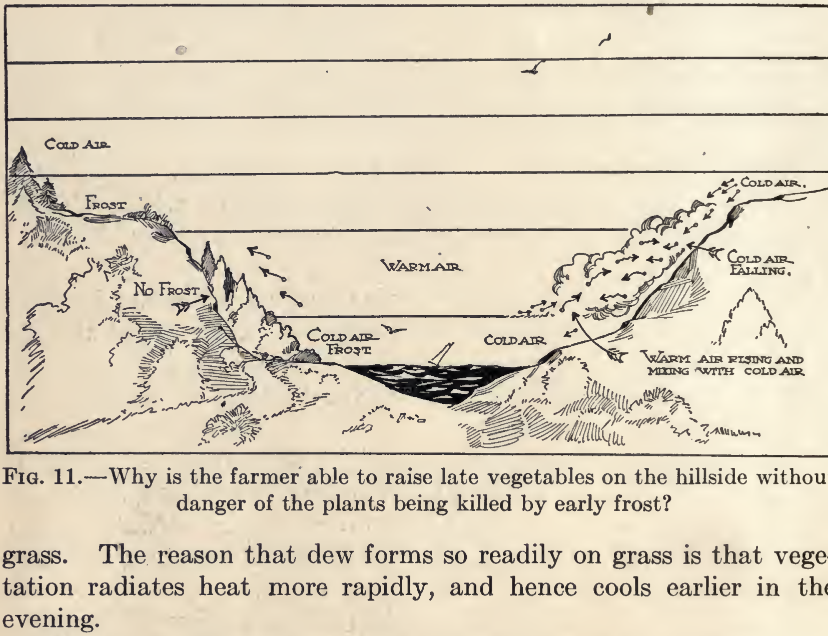


FIG. 11.—Why is the farmer able to raise late vegetables on the hillside without danger of the plants being killed by early frost?

grass. The reason that dew forms so readily on grass is that vegetation radiates heat more rapidly, and hence cools earlier in the evening.

More dew will form on a cold night than on a warm night.

Dew forms readily on faucets, ice pitchers, cellar walls, grass, and other objects which give up their heat quickly.

More dew will form on the blade of a hatchet than on the wooden handle because the wooden handle does not cool off as rapidly as the metal blade.

Frost will form in the valley and on top of the hill, while the hillside will be free from frost. Cold air is heavy, and, like

water, runs down hill into the valley. The cold air that does not reach the slope remains on the hill top. The warm air moves up the hill from the valley as the cold air takes its place. The warm air mixing with the cold air on the slope prevents the temperature from falling below 32° F.

Farmers often try to prevent frost by building fires in the field. Clouds of smoke prevent radiation, and the air is set in motion, making the cold air and warm air mix. In some parts of the country where cranberries are raised, the ground is flooded with water during the night. The water is too warm to freeze and prevents frost from forming.

Black frost is not frost in reality but frozen sap of plants. When the sun comes out, the sap thaws and the plants turn black.

Ice Storm. — A sudden jar turns to a solid a liquid which is cooled considerably below freezing. This happens in cold weather when raindrops or fog products turn to ice on coming in contact with terrestrial objects such as trees, telegraph wires, etc. The smooth coating of ice which results from rain in cold weather, to which the name glazed frost is applied, often forms heavy deposits on branches and wires, producing the familiar "ice storm."

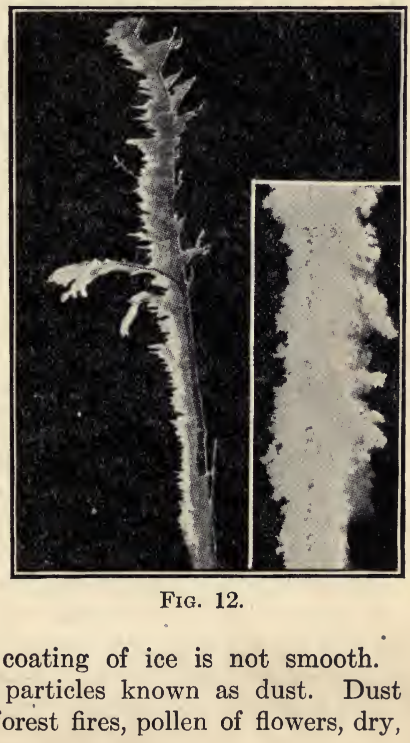


Fig. 12.

Hoarfrost or Rime.—Hoarfrost or rime is produced by deposits of rough ice or of feathery crystals which are formed by fog when the temperature is below freezing. This is unlike the familiar ice storm since the coating of ice is not smooth.

Fog.—The air is full of solid particles known as dust. Dust gets into the air from chimneys, forest fires, pollen of flowers, dry,

dusty roads, fine dust particles from volcanoes, the salt from the ocean and from all things wearing away. More dust will be found over cities where there is a great deal of smoke. This is often the cause of hazy appearances in the vicinity of cities, and also in the country after a period of drought. Hazy atmosphere is caused by the dust from the roadside and fields which is blown into the air.

These dust particles give us our beautiful sunsets and cause the air to look blue. Without them the atmosphere or sky would look black. The tiny dust particles in the air may be shown easily by darkening the room and allowing a little beam of light to enter the window.

Doctor Xavier, a Paris scientist, kept observation on individual specimens. He found that an ordinary hairpin blew away in dust after 154 days. A steel pen nib lasted just under fifteen months. A common pin disappeared in eighteen months, while a polished needle lasted two and a half years.

At sea the nuclei on which fog particles form are remarkably low in number, ranging from 500 to 3000 as compared with 150,000 in port. On certain days, however, the number rises to 50,000, the nuclei probably being produced as sale particles by the evaporation of spray from waves.

A block of dense fog 3 feet wide, 6 feet high and 100 feet long contains less than one-seventh of a glass of water, which is distributed among 60,000,000,000 drops. During the densest fog of a voyage the diameter of fog particles was found to be 10 microns; just about the limit of visibility with the naked eye.

The dust in the atmosphere is cooled off by cold currents of air. Drops of water condense on them. These tiny particles of liquid are of such minute size that they float about in the atmosphere. It might be said that fog is dew on the tiny dust particles. A splendid example of this is seen in the city of London. Fogginess has increased with the growth of London and the increase in the production of smoke. Undoubtedly the little tiny dust particles from the smoke furnish something for the water to collect upon. Sometimes this fog is so dense that all street traffic is stopped, and some of the stores are closed. It is certain that the degree of density of the fog depends chiefly upon the dust particles.

Another place which is famous for dense fogs is the Grand Banks of Newfoundland. These fogs are produced by a cold

current of air from the north which cools the moist warm air coming from the ocean.

Mist. There are times when the air is filled with a mist, or particles larger than those of fog, and yet not as large as rain drops. This mist may be due to the particles of fog being blown together until the drops become so large that they sink toward the earth.

Questions

1. Why do people say that "dew falls"?

2. At what time of day does the greatest amount of dew form? Why?

3. At what time of year do the heaviest dews occur? Why?

4. Why does an electric fan in a store window prevent frost or mist forming on the window?

5. Where do the automobile tires, shoes, clothing, machines and other articles which we use go when they "wear out"?

6. At what time of year is a hazy atmosphere most frequent? Why?

7. When will "hoar frost" form?

8. What causes fog to appear to "lift"?

9. Why do farmers feel no concern about frost on a cloudy night? On a windy night?

10. What makes the inside of a safe "sweat" on a warm sultry day?

11. What makes ice pitchers, cold water pipes, etc., "sweat"?

12. Why does ice appear to "steam"?

13. Why is there often a fog around an iceberg?

14. Why do eyeglasses become covered with moisture when brought into a warm room from a cold atmosphere?

15. What becomes of the "cloud of steam" from a kettle of boiling water?

16. What causes the white cloud from the smokestack of a locomotive?

FORMS OF WATER IN THE ATMOSPHERE

Clouds.—Fog or mist may be called nothing more than a cloud resting on the earth. Moist warm air rising high above the surface of the earth cools off as it reaches the higher levels. The water then

condenses into small particles in the air. Sometimes we see little clouds like snowballs forming in the air. These clouds are usually at the top of some rising column of warm moist air which has reached a stratum of cold air.

Clouds.—There are many forms of clouds, the most common being Cirrus, Stratus, Cumulus and Nimbus.

The subject matter in fine print is to be studied by observation. Compare these old sayings with that which actually happens. If any of the weather forecasts prove true, try to tell why.

Fig. 13.—Stratus.

Stratus.—One-fourth to three-fourths of a mile high. A haze-like cloud which consists of fog in a horizontal stratum.

A sky covered with clouds need not cause apprehension if the latter are high, and of no great density, and the air is still, the barometer at the same time being high. Rain falling under such circumstances is generally light and not of long continuance.

Cumulus.—One-half mile to 2 miles high. Woolpack clouds. Thick clouds whose summits are domes with protuberances but whose bases are flat. When the cloud is opposite the sun the surfaces usually seen by the observer are more brilliant than the edges of the protuberances. When the illumination comes from the side this cloud shows a strong dark shadow. On the sunny side of the sky, however, it appears dark with white edges. The true Cumulus shows a sharp border above and below.

Well-defined cumulus clouds, forming a few hours after sunrise, increasing toward the middle of the day, and decreasing toward evening, are indicative of settled weather. If, instead of subsiding in the evening and leaving the sky clear, they keep increasing, they are indicative of wet.

FIG. 14.—Cumulus.

When the cumulus clouds are smaller at sunset than they were at noon expect fair weather.

When cumulus clouds become heaped up during a strong wind at sunset, expect thunder during the night.

When a heavy cloud comes up in the southwest and seems to settle back again, look out for rain.

FIG. 15.—Nimbus.

Nimbus.—About 1 mile high. Rain clouds. Dense masses of dark, formless clouds with ragged edges from which rain or snow

is generally falling. Through the breaks in these clouds there is almost always seen a high sheet of Cirro- or Alto-stratus. If the mass of Nimbus is thrown up into small patches, or if low fragments of clouds are floating much below the great Nimbus, they may be called Fracto-nimbus or Scud. Light Scud clouds indicate wind.

Clouds flying against the wind indicate rain.

If clouds float at different heights and rates, but generally in opposite directions, expect heavy rain.

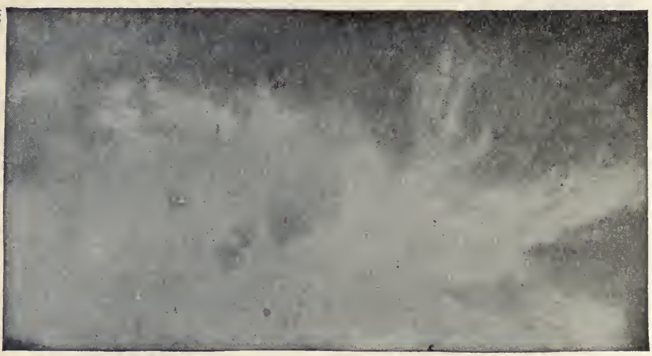


Fig. 16.—Cirrus.

Cirrus.—About 5 to 7 miles high. Feather-like clouds high up in the air Cirrus clouds are usually composed of ice particles. They are often called Mare's Tail.

If cirrus clouds dissolve and appear to vanish, it is an indication of fine weather.

The longer dry weather has lasted the less likely is rain to follow the appearance of cirrus clouds.

If cirrus clouds form in fine weather with a falling barometer, it is always indicative of rain.

When threads of cirrus clouds are brushed back from a westerly direction, expect rain and wind.

If the streaks of cirrus clouds point upward, they indicate rain. If downward, they indicate wind and dry weather.

Cirro-Stratus.—2 to 6 miles high. A fine whitish veil, sometimes quite diffuse, giving a whitish appearance to the sky, and called by many, Cirrus Haze. Sometimes it shows more or less

distinct structure, exhibiting tangled figures. This cloud formation often produces halos around the sun and moon.

FIG. 17.—Cirro-stratus.

When cirrus merge into cirro-stratus, and when cumulus increase toward evening and become lower, expect wet weather.

Cirro-Cumulus.—3 to 6 miles high. A collection of fleecy clouds. Small white balls and wisps without shadows, or with very

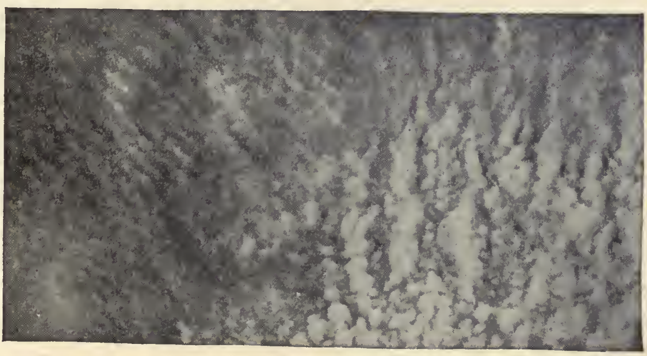


FIG. 18.—Cirro-cumulus.

faint shadows, which are arranged in groups and often in rows. Many people call this a "mackerel sky."

When cirro-cumulus clouds appear in winter, expect warm and wet weather.

Mackerel clouds in sky,
Expect more wet than dry.

A mackerel sky,
Not twenty-four hours dry.

Mackerel scales and mare's tails
Make lofty ships carry low sails.

Fracto-stratus.—Fracto-stratus is the true stratus torn by the wind or mountain summits into irregular fragments.

Fracto-cumulus.—These are broken masses of cloud which are continually changing in form. They are caused by the true Cumulus being torn by strong winds into detached parts. Fracto-cumulus clouds present continual changes.

Fig. 19.—Strato-cumulus.

Strato-cumulus. One-half to 3 miles high. Large balls or rolls of dark clouds which frequently cover the whole sky, especially in winter, and give it at times an undulating appearance. The stratum of Strato-cumulus is usually not very thick. A blue sky often appears in breaks through it. Between this form and the Alto-cumulus all possible gradations are found. It is distinguished from Nimbus by the ball-like or rolled form. It does not tend to bring rain.

Cumulo-nimbus. One half to $4\frac{1}{2}$ miles high. Thunder cloud; shower cloud. Heavy masses of clouds rising like mountains. From their base generally fall local showers of rain or snow and sometimes hail or sleet. The upper edges are either of compact

FIG. 20.—Cumulo-nimbus.

Cumulus-like outline and form massive summits surrounded by delicate false Cirrus, or the edges themselves are drawn out into Cirrus-like elements. This last form is most common in spring showers.

FIG. 21.—Alto-cumulus.

Alto-cumulus. 2 to 4 miles high. Dense, fleecy clouds. Large whitish or grayish balls with shaded portions, grouped in flocks or rows, frequently so close together that their edges meet. The different balls are generally larger and more compact toward

the center of the group, and more delicate and wispy on its edges. They are very frequently arranged in lines in one or two directions.

When a heavy cloud comes up in the southwest, and seems to settle back again, look out for a storm.

Clouds upon hill, if rising, do not bring rain; if falling, rain follows.

FIG. 22.—Alto-stratus.

Alto-stratus.—3 to 5 miles high. With patches of Fracto-nimbus. Thick veil of gray or bluish color exhibiting in the vicinity of the sun and moon a brighter portion. They may produce coronae without producing halos.

Alto-stratus shows gradual transitions to cirro-stratus. Fracto-nimbus is more popularly known as Scud, and consists of small portions of cloud at a very low level which travel at some speed.

VARIETIES AND SPEED OF CLOUDS

Height.	Name.	Description.
Sea level up to 3,000 ft.	Stratus..............	Elevated fog, so called.
4,500 to 6,000 ft.	Cumulus..........	Round, tower-like clouds with round tops and flat bases.
4,500 to 24,000 ft.	Cumulo-nimbus....	Round, tower-like clouds with round tops and flat bases.
6,400 ft............	Strato-cumulus.....	Rolls of dark clouds.
6,400 ft............	Nimbus...........	Masses of dark, formless cloud.
10,000 to 21,000 ft....	Cirro-cumulus.....	Fleecy cloud, a "mackerel sky."
27,000 ft. (average)...	Cirro-stratus......	Fine whitish veil, giving halos around sun and moon.
27,000 ft. (average)...	Cirrus............	Isolated feathery white clouds.

Cloud Level.	Height in Feet.	Average Speed Miles per Hour.
Stratus	1,676	19
Cumulus	5,326	24
Alto-cumulus	12,724	34
Cirro-cumulus	21,888	71
Cirrus	29,317	78

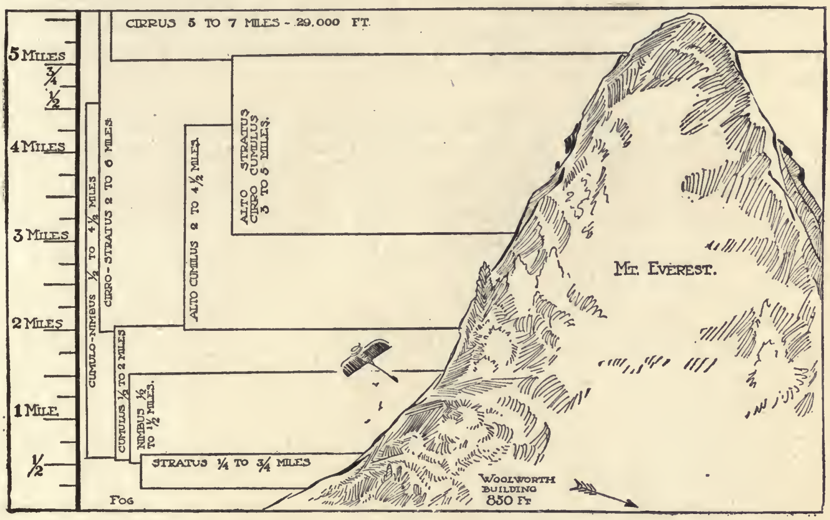


FIG. 23.—What kind of clouds forms nearest the earth? What kind of clouds forms farthest from the earth? When would a cloud be called a fog? What kind of clouds has the greatest range of heights? What kind of clouds have you in the sky to-day? What is the average height? What do they predict?

WATER CONDENSING HIGH IN THE AIR

Why Air Loses its Moisture.—Warm air can retain a greater quantity of vapor in an invisible state than cold air.

At freezing point (32° F.) the air can sustain $\frac{1}{160}$ of its weight of transparent vapor, and for every increase of 20° its retaining capacity is practically doubled. Thus a cubic foot of air saturated with

vapor at 32° F. weighs 2.113 grams (troy); at 70° F. it weighs 7.980 grams, and at 80° F. 10.933 grams.

If the atmosphere is suddenly cooled from 80° to 70° about 3 grams of water will condense out of every cubic foot of saturated air. This change of temperature of saturated air is the primary cause of rain.

It has been estimated that in a cubic inch of smoke there are as many as 12,000,000,000 nuclei around which moisture may collect. It is possible that every rain drop is built around a nucleus, or center of condensation. From some observations in England and at Pittsburg it was found that from 500 to 1900 tons of dirt per square mile were brought down by rain in one year.

Effects of Altitude.—The temperature decreases about 1° F. for every 300 feet of ascent. There is less ground to radiate heat into the upper layers of atmosphere, and the warm air which comes up from the earth in the valleys cools very rapidly when it reaches the upper strata of air. The top of a mountain 15,000 feet high, at the equator, would be about 50° cooler than the land at its foot.

Rain.—Clouds increase when more vapor is turned into mist or fog. Minute drops crowd together, making larger drops which again join with others, making still larger drops. This can be illustrated by the dew experiment which was described on page 21. First, mist is formed, then tiny drops appear, then larger drops begin to run down the can. The air cannot hold up the large drops, and they fall to the ground as a shower of rain. Air in circulation can support a heavier weight than air which is still. Heavy winds will keep rain particles up in the air until they become very large. This is the cause of the difference in size of raindrops.

Rain, briefly speaking, is caused by the chilling of air which contains a certain amount of moisture. This chilling may take place either through the rising of air into higher and colder levels from its meeting a colder current of air, or through its contact with colder surfaces, such as mountains. Rain is often caused by the rushing of air from the low land up over the mountain. Some of the heaviest rainfalls take place on mountains near the sea. The air over the ocean gets thoroughly soaked with vapor which, while warmed, it can carry. Then it suddenly comes up against a moun-

tain range, and rushes upward into a colder atmosphere, losing heat as it does so. The air can no longer hold the moisture, and torrents of rain result.

A gallon of rain weighs 8.3 pounds and will cover an area of 2 square feet to the depth of 1 inch. One inch of rainfall gives 113 tons of water to the acre, or 72,600 tons to the square mile. In Khase Hill in Bengal, India, the rainfall is the greatest in the world, exceeding 600 inches yearly.

Often clouds appear over the desert of Sahara and rain really starts to fall, but the air is so dry that before it reaches the earth, the moisture evaporates.

The rivers come from the clouds, for clouds pour down rain, rain fills the rivers, and the rivers supply the sea. The sea surface goes into the air as vapor, and the vapor becomes clouds; so, whether we start with mountain rivulet or clouds, the circle is complete, for we always return to our starting point.

Every school should have a rain-gauge placed in an exposed position, but well protected from winds.

Hail.—When raindrops become frozen in their passage through the air, they fall as hail. Frequently a strong wind blows the raindrops back, and other drops of rain unite with them. This process continues until the hail becomes so large that the cold current of air which is freezing the rain is not strong enough to force the hailstones back, and they fall to the earth.

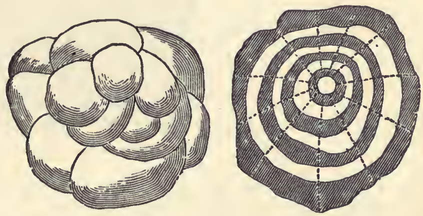


Fig. 24.—Structure of a Hailstone.

The size of the hailstones will depend on how strong the current of air is which is blowing them back. When moisture condenses at a temperature below freezing point, minute crystals are formed. When moisture condenses near the earth, below freezing, frost is produced. Sometimes we see branches of trees, the telephone wires, the clothes lines, etc., covered with beautiful ice crystals, often called hoar frost. This is really produced by the direct deposit

of ice crystals from the atmosphere. The air has cooled below freezing.

A sudden jar turns a supercooled liquid instantly to a solid; and thus it happens that, in cold weather, raindrops or fog particles turn to ice on coming in contact with trees, telegraph wires, and the like, giving us the interesting spectacle of the "ice storm."

Snow.—When condensation occurs at a temperature below freezing the vapor will crystallize and form snowflakes or ice needles of varied forms. In milder weather, when snow falls into a warm stratum of air, it partly melts and reaches the ground as sleet or slush.

Sometimes during our summers snow forms in the upper part

FIG. 25.—Snow-crystals.

of a thunder stormcloud, but melts and changes into rain before it reaches the earth.

To give an idea of the amount of water that falls on an acre of ground, the following will be of interest:

0.01 inch of rain equals	62,726 cubic inches or	1.1 tons
0.05	312,636	5.6
0.10	627,264	11.3
1.00	6,272,640	113.0
2.00	12,545,280	226.0
5.00	31,363,200	565.0

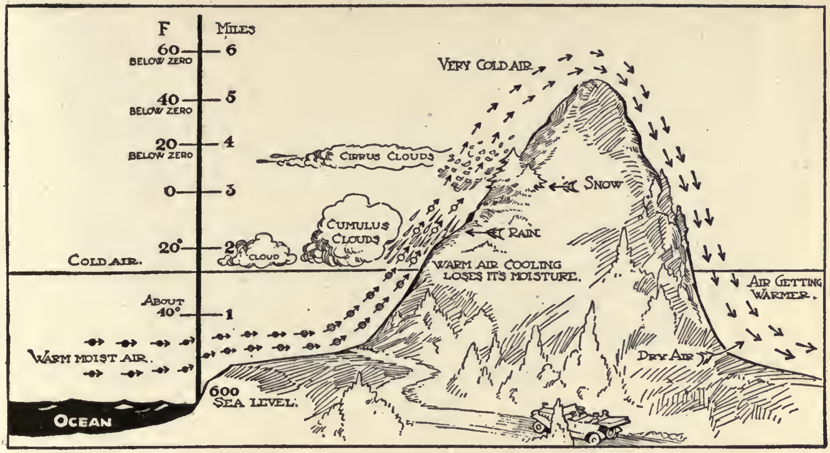


FIG. 26.—The black dots on the arrows represent air laden with moisture. Arrows without dots represent air comparatively free from moisture.

QUESTIONS

1. Why is the air coming in from over the ocean full of moisture?

2. Why will clouds form as air from the ocean rushes up the side of a mountain?

3. Why do rain and snow fall on the side of the mountain?

4. Why is the air so dry on the side of the mountain away from the ocean?

5. Why is the rainfall greater on the ocean side of the mountain than on the plains behind the mountain?

6. Examine the relief map of the United States, and explain how different parts of the country get various amounts of rain.

7. Account for the great American Desert.

8. What is meant by " the sun is drawing water "?

9. What is meant by " The clouds are breaking away "?

10. What effects are produced by the temperature of the air 3 or 4 miles above the earth?

11. What facts do you consider most important in this chapter?

FIG. 27*A*.

QUESTIONS ON THE MAPS

What part of the country is mountainous?
Where are the highest mountains?
What part of the country has the greatest amount of rainfall?
What part of the country is affected by mountains?

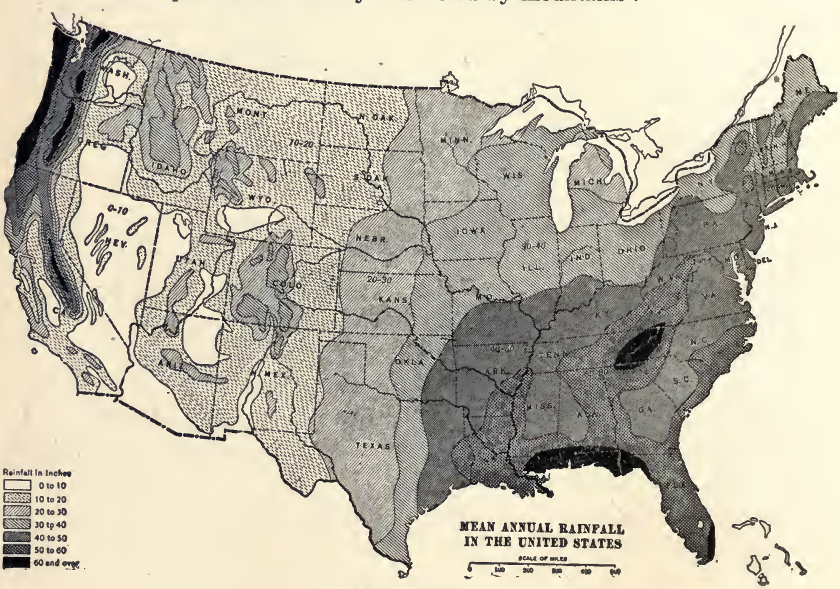


FIG. 27*B*

CHAPTER III

THE ATMOSPHERE

ATMOSPHERIC PRESSURE

Close a bottle full of water with a one-hole rubber stopper through which runs a glass tube. If we try to suck the water out of the bottle, we find it is impossible to do so until the stopper is loosened and air allowed to come in contact with the surface of the water.

Our whole earth is enveloped by a marvelous ocean of air, an ocean of gaseous matter at least one hundred times as deep as the water oceans. This air is pressing down on us with tremendous weight. It does not crush us because our blood pressure, together with the air in our body, is pressing out as hard as the air is pressing on us.

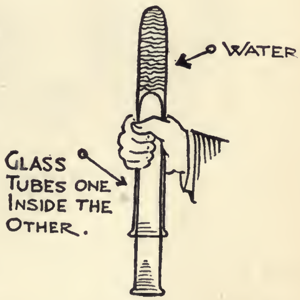


FIG. 28.—Why will the smaller test tube rise into the larger?

Fill a test tube about half full of water. Find a smaller test tube which will just fit inside the larger one. Invert the two with one inserted in the other. As the water runs out, the inner test tube must rise to fill the space. Why?

FIG. 28*A*.

Fill a tumbler nearly full of water, place a small sheet of thick paper over the top, and hold it there while you invert the glass. Remove the hand.

Why does the paper remain on the mouth of the glass?

What holds the water in the glass?

What is trying to press the paper off?

Put the tip of your pencil carefully under the paper just enough to make a slight opening between the glass and the paper.

Why does the paper come off so quickly?

What other things do you find out from this experiment?

Use of Air Pressure.—Air pressure is very useful to us. When we wish to remove the dirt from our carpet, we remove the air from the vacuum cleaner by a motor and fan, and as the air rushes in to fill the place from which the air was removed, it carries the dust and dirt along with it.

Why is it necessary to have an attachment that fits closely to the carpet?

Why does the motor push the air into the bag?

Why is it necessary to have a different attachment for hardwood floors, one which does not fit as closely to the floor?

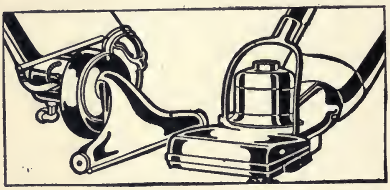


FIG. 29.

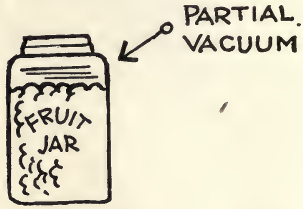


FIG. 30.

Why is it wrong to say the motor sucks the dirt up from the floor?

Preserving Fruit.—When we wish to preserve fruit, we heat the can and drive out the air. The can cover is then put on with a rubber ring to prevent the air getting in. As the can cools off, a partial vacuum is formed in the can, and the outside pressure is great enough to hold the cover on securely.

Pumps.—A very important use of air pressure is made in the pumps used in wells. As we work the handle up and down, the air is removed from the barrel of the pump. The air pressure on the surface of the water then presses the water up the pipe.

As the handle in Fig. 31, (4) moves down, why is valve *B* closed and valve *A* open?

When the handle moves up in Fig. 31, (3) why does valve *B* open and *A* close?

Why does the water start to come up from the well?

Why does water go up through valve *A* as the handle moves down?

What movement of the handle will bring water up to the spout to make it run out?

What kind of a pump is the heart?

What kind of a pump is used for spraying trees?

What kind of a pump is used for tire pumps for automobiles and bicycles?

When would a force pump be used in a home?

What is the difference between a force pump and a lift pump?

What is meant by an exhaust pump?

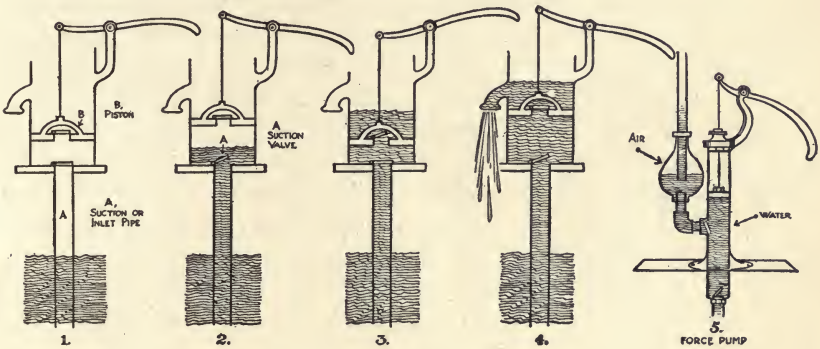


FIG. 31.

Why does the gasoline in an automobile tank at the rear of the car pass easily into the engine when a vacuum is used?

What causes the 'vacuum'?

Why is there a small hole in the cap of the tank?

Siphon.—

Partly fill a flask with water. Close it with a two-hole rubber stopper. Through one hole insert a glass tube which has been drawn out to a jet, so that the jet is inside the flask. Let the other end of the tubing dip into a jar of water. Insert in the other hole another piece of glass tubing which extends just through the stopper. Attach to this a piece of rubber tubing the other end of which dips into water in jar *B* on the floor. Invert the flask and fasten it to a ring stand. Fig. 32.

As the water runs out of the flask, the air pressure will be reduced inside the flask. The air on the surface of the water in

the jar *A* will force the water up through the jet in the flask, forming a fountain.

Why does the water run out of flask *F* into jar *B*?

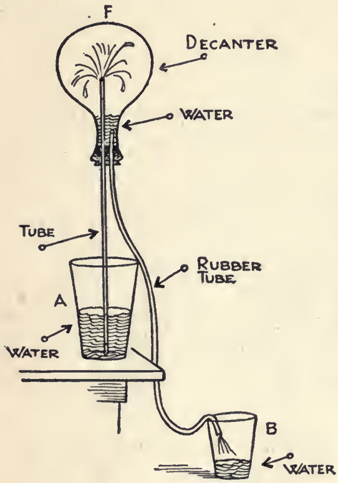


FIG. 32.

Why will the water in *A* rush up into the flask *F* forming a fountain?

What happens when the jar *B* is raised to the same height as *A*?

When it is raised higher than *A*?

Make a siphon with a piece of glass tubing by bending the tubing in a fish-tail Bunsen burner. Fig. 33. Is it necessary to make one arm longer than the other? Why must the siphon be filled with water before it will work? Why will the water stay in the siphon if the finger is placed over the end?

Self-starting Siphon. Among the many useful pieces of apparatus which make use of air pressure is the self-starting siphon.

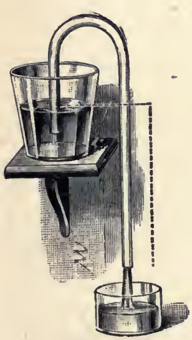


FIG. 33.

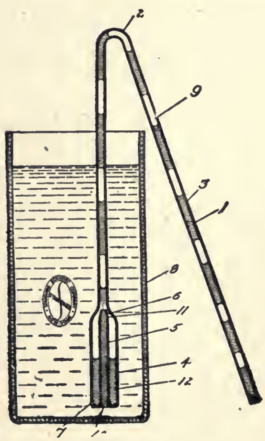


FIG. 34.

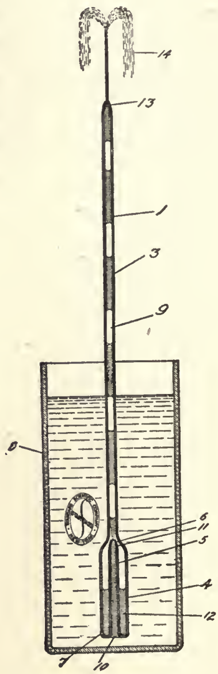


FIG. 35.

The self-starting device is shown in Fig. 34, and consists of a bulb (4) sealed into the lower end of the tube (2) and an inner tube (5) sealed into the base of the bulb and reaching into the opening of the bulb at the top. Here the end is somewhat constricted, and its size and position with respect to the top of the bulb are so adjusted that an "air trap" is produced at (6). A small opening (7) is made at the lower part of the bulb.

If the bulb be placed at a considerable depth in the liquid to be siphoned, the liquid flows into the bulb through (7) and displaces the air, which, with the water passing through the inner tube (5), rises in a broken column in tube (2) and flows out through the delivery tube.

The wide application of the self-starting siphon is apparent especially in chemical laboratories, drug stores, manufacturing and other establishments where liquids and various solutions are in constant use. In transferring corrosive poisons or valuable liquids it obviates accident or waste.

Air Has Weight. Place on each end of a stick a flask closed by a rubber stopper, and balance the stick carefully. Remove the stopper from one of the flasks and heat the flask.

The air will expand and some of it will come out. Replace the stopper. The stick will no longer balance. The air in the heated flask does not weigh as much as before. Air has weight.

Another interesting way to show that air has weight is to balance an old electric light bulb on a stick. Remove the bulb and with a blow pipe blow a

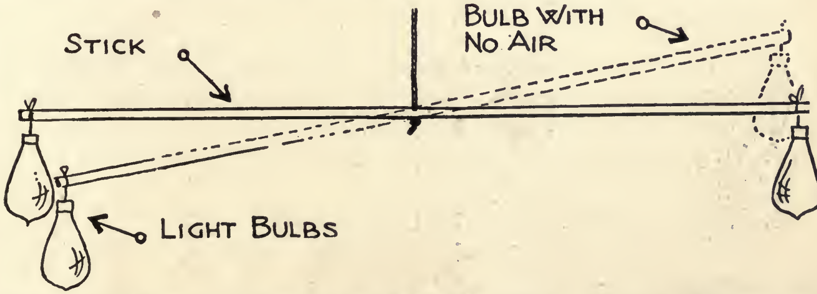


FIG. 36.—Balance two electric light bulbs on a stick. With a blow-pipe and flame carefully make a hole in one. Why will they no longer balance? A nitrogen-filled bulb should not be used. Why?

hole in the side of the bulb. Air will rush in, for the bulb was, as nearly as possible, a complete vacuum. If the bulb is now placed on the stick it will no longer balance. The air which has rushed into the bulb has weight. Dry air weighs about $\frac{1}{4}$ oz. per cu. ft. at sea level, or 13 cu. ft. weigh about 1 lb.

Air exerts pressure equally on all sides of objects. This has not always been known. An Italian scientist by the name of Torricelli found out how much the air weighs, or presses down on us.

Questions

1. What makes water gurgle from a jug? How can the gurgling be prevented?

2. Why is it better to have two holes in an oil can? in the stopper of a large ink bottle?

3. On what principle does the non-skid tire work?

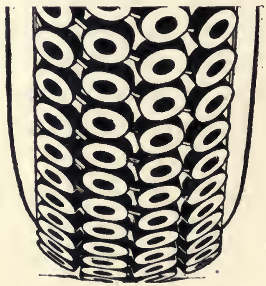


Fig. 37.—Each little pocket in the tire becomes a partial vacuum as the tire comes in contact with the pavement: a use of air pressure to prevent skidding.

4. Why is it necessary to force a knife under the cover of a fruit jar before the cover will come off? What would be the effect on the cover if the air were removed around the jar?

5. Why do papers and dirt rise in the air after a swiftly moving train?

6. Why is it possible for a fly to walk on the wall?

7. Explain the action of a fountain pen filler; self-filling fountain pen.

8. Why are you able to walk with tennis shoes more easily in rough places than with high-heeled shoes ?

9. Why will a swinging door open slightly if some one opens a door quickly in another part of the room?

10. Why is it difficult to drink from a small-mouthed bottle?

11. What makes soda water rise in a straw?

12. Why would it be impossible to suck up soda water through a piece of glass tubing extending through a perforated rubber stopper, if the stopper closed the bottle tightly?

13. What is meant by suction shoes?

14. How does the boa-constrictor use atmospheric pressure to swallow its food?

15. Why does it tire one to walk in the mud?

16. Why is it necessary to use on a vacuum cleaner one kind of an attachment for cleaning hardwood floors, and a different kind of an attachment for carpets?

17. About what is the weight of the air in your room?

18. Why will not the cover of a preserving jar stay on securely if the cover is put on when the can is cold?

19. Why will two glasses stick together if one is placed within the other immediately after washing them with hot water?

20. If two books are placed on the table about 2 inches apart, and a sheet of paper placed over them, explain why the paper sinks between the books when one blows between them.

21. Why does the liquid from an atomizer rise in the tube when air is forced over the mouth of the tube by pressure upon the rubber bulb?

MEASURING ATMOSPHERIC PRESSURE

The Barometer.—The barometer, which only recently has come into popularity, was "invented" nearly three hundred years ago.

The work in connection with this invention is very interesting. It seems that Galileo Galilei, an Italian philosopher and mathematician (Born 1564—Died 1642), was asked, toward the end of his life, to explain why water could not be raised in a suction pump to a greater height than 32 feet.

He was led to believe that the pressure of the air did not exceed the pressure of a column of water 32 feet high; but subsequently he devised an experiment to ascertain the pressure of the air.

His apparatus, which was placed in an inverted position, consisted of a tube with a very smooth interior in which a closely fitted piston was placed. Weights were applied to this piston to see how much pull was necessary to draw it down.

Before his death he advised his pupil (Evangelista Torricelli) to continue these experiments.

Torricelli's decisive experiment ascertained the length of a column of mercury sustained by the same cause, whatever it might be, which supported the column of water.

As the weight of mercury is 13.6 times greater than that of water he reasoned that the height of the mercury column should be only about $\frac{1}{13}$ as high as the water column.

Torricelli proved his idea on the subject by taking a glass tube about 3 feet in length, closed at one end, and filled with mercury. Putting his finger on the open end, he inverted this tube in a small bowl, containing mercury, and when he removed his finger, he found that the mercury sank in the tube until its level was about 29 inches above the level of the mercury in the bowl.

Otto von Guericke invented the water barometer by erecting a long tube reaching from a cistern in the cellar up through the roof of his house in Magdeburg, Germany. A wooden image was placed within the tube, floating upon the water. On fine days this novel weather-prophet would rise above the roof-top and peep out upon the queer gables of the ancient city, while in foul weather he would retire to the protection of the garret. The accuracy of these movements attracted the attention of the neighbors. Finally, becoming suspicious of Otto's piety, they accused him of being in league with the devil. So the philosopher removed his "wooden man" and the staid old city was once more at peace.

Measuring the Pressure of the Atmosphere.—Take a long hollow glass tube and put one end in a dish of mercury. Attach an air pump to the upper end of the tube and remove the air. The mercury will rise in the tube to about 30 inches at sea level, but no higher. Now a cubic inch of mercury weighs about .49 of a pound. The air is pressing on the surface of the mercury hard enough to make the mercury rise to a height of about 30 inches. Then the air must be pressing about 14.7 pounds per square inch. This great pressure of 14.7 pounds per square inch amounts to a tremendous total when we consider the number of square inches on our bodies.

Below is a table of the average number of square feet on the body. How much pressure does the air exert on your body?

TABLES SHOWING AVERAGE WEIGHT AND SKIN SURFACE

Boys.		Men.	
Weight in Pounds.	Surface in Square Feet.	Weight in Pounds.	Surface in Square Feet.
41.09	7.9	131	15.92
45.17	8.3	133	16.06
49.07	8.8	136	16.27
53.92	9.4	140	16.55
59.23	9.9	143	16.76
65.30	10.5	147	17.06
70.18	11.0	152	17.40
76.92	11.6	157	17.76
84.85	12.4	162	18.12
94.91	13.4	167	18.48
		173	18.91
		179	19.34
		185	19.89
		192	20.33
		200	20.88
Girls.		**Women.**	
39.66	7.7	119	14.82
43.28	8.1	122	15.03
47.46	8.5	124	15.29
52.04	9.2	127	15.50
57.07	9.7	131	15.92
62.35	10.2	134	16.13
68.84	10.7	139	16.48
78.31	11.8	143	16.76
		147	17.06
		151	17.34
		155	17.64
		159	17.92

Blood Pressure.—Blood pressure for children and young people is about 17 pounds per square inch or about 2 pounds more than the

atmospheric pressure. As people get older, the blood pressure increases, sometimes as much as 3 or 4 pounds. Insurance companies as well as physicians often determine the probable length of a person's life by the blood pressure. If a person has high blood pressure at an early age, it usually indicates ill health and short life.

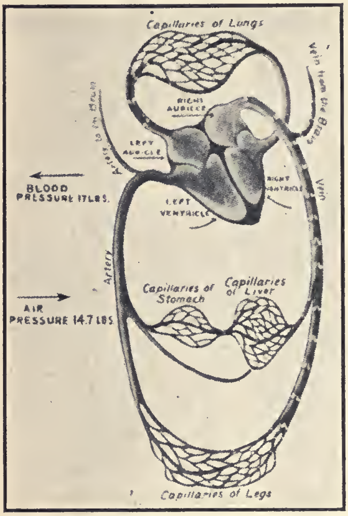


FIG. 38.—How much greater is the blood pressure than the atmospheric pressure? Why is this necessary?

Making the Barometer.—Fill a glass tube about 3 feet long with mercury and invert it in a small dish of mercury. The mercury will drop until it stands at about 30 inches at sea level, which shows that the air pressure is great enough to make the mercury rise, but it is impossible for the air to make the mercury rise to fill the vacuum at the top.

FIG. 39.—Barometer.

Air Pressure Varies at different heights: It has been estimated that the atmosphere extends above the earth about two hundred miles, possibly more. At the bottom of this ocean we humans live and crawl about, ordinarily on the flat lower levels at the very bottom. Sometimes, after much toil, we climb the little ridges and mounds called mountains, little when compared with the depth of the atmosphere, though not very small when compared with ourselves. The highest of the high mountain peaks are well to the bottom of this ocean of air. This air is constantly growing rarer the higher we get above the earth's surface. The greater part of the weight of the atmosphere is within three miles of the earth.

When airmen ascend too high, the blood comes out through the thin membranes of the nose and eyes, as the inside pressure is too great.

Men often go down under water in a caisson full of compressed air, which keeps the water out. The caisson is divided into chambers. The men go from chamber to chamber, slowly allowing their bodies to adjust themselves to the increased air pressure. *Caisson disease* or *"the bends"* is due to rapid passage from high to low atmospheric pressure such as that experienced by men working in caissons under the water, on bridge-piers or tunnels. When they come out into the open air the sudden release of pressure fills the blood with bubbles of dissolved gas in much the same way as soda water in a bottle fills with bubbles when the pressure is released by removing the stopper. It is necessary that the release of pressure should be sudden; hence an aviator would not suffer from "bends" from any increase in altitude due to climbing in an aeroplane. "The bends" is due to the sudden release of a very high pressure which forces an abnormal amount of nitrogen into the blood. When a man has worked in compressed air in a diving-bell in the depths of the sea or in a caisson in water, the nitrogen which is absorbed is dissolved in great quantities in the body fluids. When this pressure is lowered, as it is when a man returns to the surface, the nitrogen begins to work into the joints, nerves and brain in the form of bubbles so rapidly as to cause intense pain, paralysis and sometimes death.

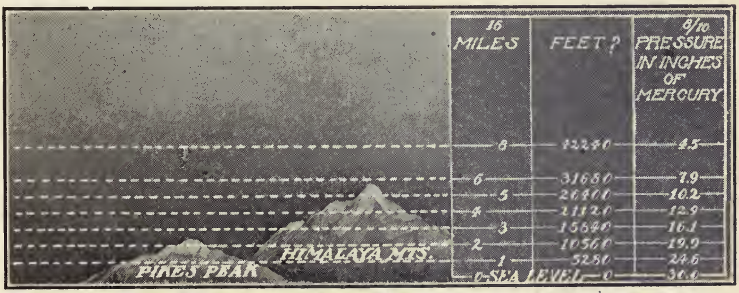


FIG. 40.—What do you think about the amount of air 25 miles above the earth? What figures on the diagram tell us that the density of the air rapidly decreases as we ascend? It is thought by some that particles of air may pass off to and beyond the planets.

A French author, Blaise Pascal, became interested in Torricelli's discovery. It occurred to him that if the atmospheric pressure supported the mercury in the tube, as shown in Torricelli's experiment, the height of the column of mercury in the tube should increase or decrease if the pressure increased or decreased.

He took up his idea with Périer, his brother-in-law, who lived near the high conical mountain of Puy-de-Dôme, and requested the latter to test his theory upon this mountain.

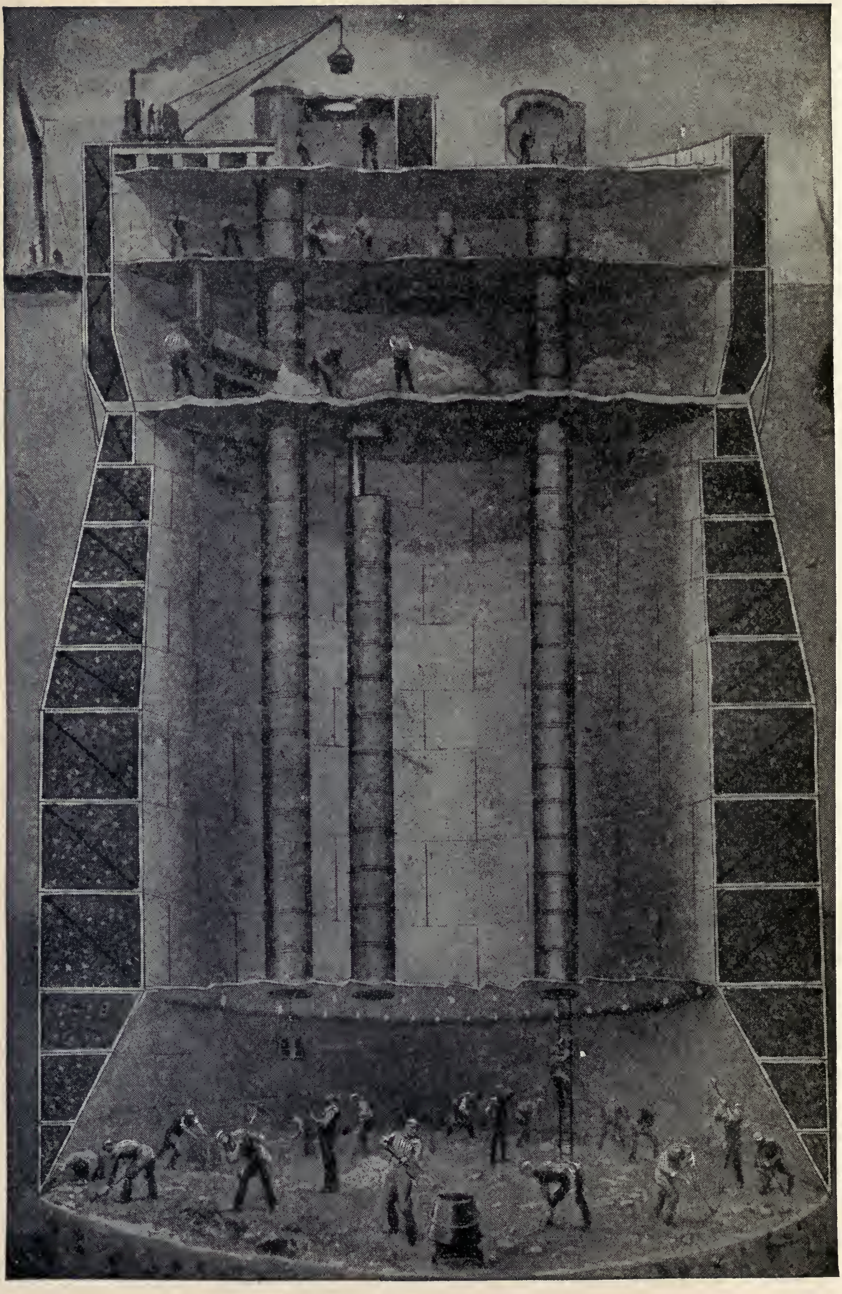


FIG. 41.—Men work in a Caisson under water.
Courtesy of Child's Book of Knowledge.

Périer manufactured two tubes, filled them with mercury and observed them in his garden at Clermont, the height of the mercury in the tubes being 26 French inches and $3\frac{3}{4}$ lines.

Leaving one behind to be observed during his absence, he took the other up the Puy-de-Dôme and, at the summit, observed that the mercury had fallen in the tube to 23 inches and 2 lines. Noting the tube as he returned to the lower levels of the mountain, he found that the mercury continued to rise until by the time he reached his starting-point the mercury stood at its original level of 26 inches and $3\frac{3}{4}$ lines, at which point that in the other tube had stood during his absence.

Satisfied beyond measure with the result, Pascal proposed this process as a means of determining the height of any one place above another. Thus the "barometer" was born, and sent on its career throughout the civilized world.

The most distinguished men of science have worked to develop from this crude but original instrument of three hundred years ago the fine instrument of the present day; yet the modern instrument is nothing but the original "tube inverted in a cup of mercury" with many refinements.

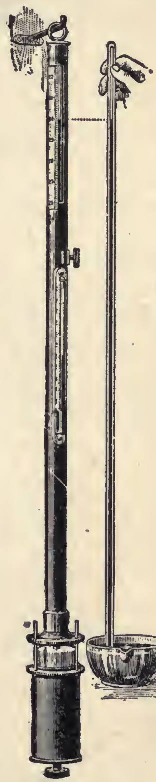


Fig. 42.—A mercurial barometer.

Aneroid Barometer.—The barometer is also used to tell how high aeroplanes ascend, as the higher they go the lower the barometer will drop. They cannot, of course, use a mercury barometer. The type of barometer used is called an aneroid barometer (non-fluid).

Construction

A. Metal or base plate upon which parts are set. Fig. 44.

B. Corrugated chamber of German silver (metal thickness 0.0004 inch), from which all air is exhausted. It is secured to the plate *A* by a screw which passes through the plate, and to which a nut is fastened.

C. Bridge which spans vacuum chamber *B*.

D. D. Adjusting screws which are used to either raise or lower the bridge, thereby altering the tension on chamber *B*.


ASCENT
3000
Surveying Aneroid
Short & Mason Ltd.
LONDON.
Tycos
Compensated

FIG. 43.

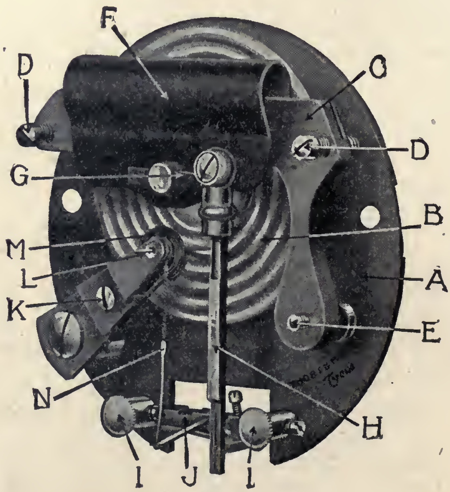

F
D
C
D
G
B
M
L
A
K
E
N
H
I
J
I

FIG. 44.

E. Adjusting screw which raises bridge *C* either up or down. The head of this screw is seen in the back of all aneroids.

F. Steel spring which slides in back of bridge *C*.

G. Knife-edge (triangular or square steel rod). This passes through the stud of the vacuum chamber and tends to open it by pulling strongly upwards.

At this point it is interesting to note that the mechanism is already sensitive to changes in atmospheric pressure. As the vacuum chamber is similar

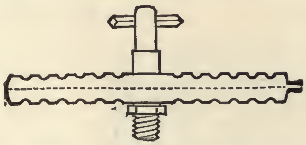


FIG. 45*a*.—Before exhausting air.

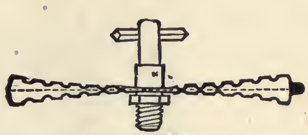


FIG. 45*b*.—After exhausting air.

to a small circular metal box (closely resembling two lids of a tin can soldered together at their edges) it will, when exhausted of air, collapse. If we pull it from the bottom and also from the top, we pull it open, but when we let go it collapses again.

As the under side is secured to the base plate *A* and the upper side is secured to the strong spring *F*, the action is the same as the illustration just given with the two tin can lids, viz., the strong spring "opens" the vacuum chamber and holds it open.

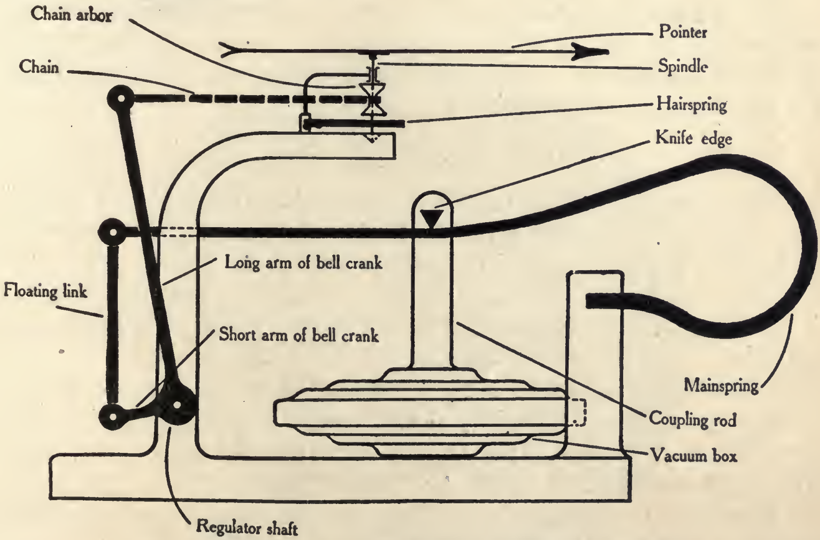


FIG. 46—Interior movements of an Aneroid Barometer.

If we now increase the pressure or weight on the vacuum chamber, it pulls the spring down with it; if we decrease the pressure, the spring opens it up proportionately.

It is now easy to see that this spring moves up or down as the air pressure decreases or increases. If we secure an arm to it we will magnify its movement at the end of the arm.

H. Bar, or arm, compensated for temperature, which at its end magnifies movement of the spring *F*.

L. L. Two supports or pillars fitted to plate *A*.

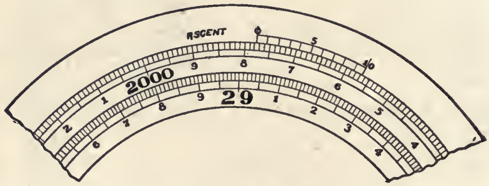


FIG. 47.

Description.—The dials are divided into inches of mercury pressure. If the barometer is standing at 29 it means that at that point of observation mercury would be supported at a height of 29 inches in a tube, as explained in Torricelli's experiment.

The Pressure of the Air Does not Decrease Evenly.—By the table it will be seen that the drop in the barometer between 31 and 30 inches represents a rise of 890 feet. Between 17 and 18 inches the rise would be 1580 feet.

QUESTIONS

1. During a stormy day the barometer dropped 1.5 inches. How far would a water barometer have dropped? What was the pressure of the atmosphere in pounds per square inch?

2. How far would a perfect suction pump lift water in your town?

3. Why does the barometer work as well inside as outside of a building?

4. Why is it better to keep a barometer in the same room and inside of a building, especially if it is not compensated?

5. How could one remove the water from a boat on the beach with a rubber hose?

Why is it impossible to use the same method to get the bilge water out of a boat floating on the water?

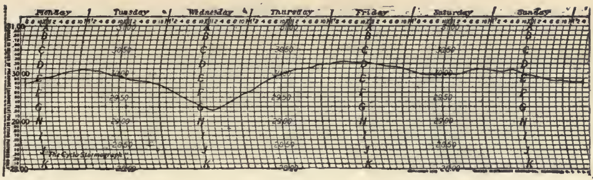


FIG. 48*a*—Sheet from the Stormograph. What was the Barometer doing Tuesday afternoon? What was it during Thursday morning? What does each line made indicate?

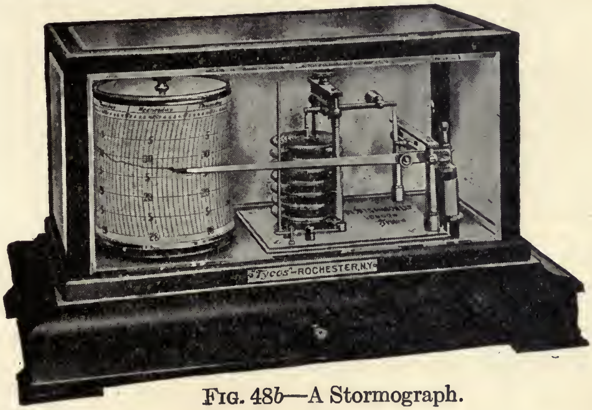


FIG. 48*b*—A Stormograph.

FIG. 48*c*—Aviator's Barometer for measuring heights.

6. What is the pressure of the atmosphere in pounds per square inch when the barometer reads 29, 29.5, 30, 30.2?

7. Why does water stay up in a bottle which is used as a drinking fountain for chickens?

8. Explain the action of a drinking fountain made of an ice chest and an inverted 5-gallon bottle.

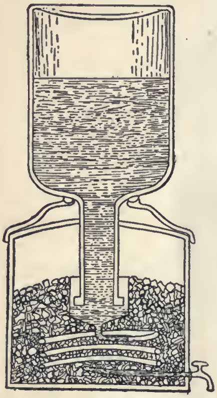


FIG. 49.—Why does the water stay in the large bottle? Why are bubbles seen rising in the water when a glass of water is drawn?

9. Could you siphon water over your school building?

10. How much force would be required to pull Von Guericke's hemispheres apart? (Air pressure on a circle 22 inches diameter.)

11. Why do clothes bulge when being pressed into a boiler full of water?

Problem to look up.

12. How do the pneumatic tubes work which carry money in department stores and transport mail in cities?

13. What causes the noise when a thimble is suddenly removed from a finger?

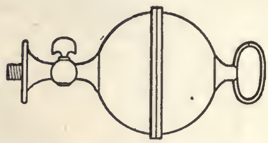


FIG. 50*a*.—Magdeburg or Von Guericke's hemispheres.

14. Why is it necessary to have more than one hole in a cocoanut in order to get the milk?

15. Why does smoke sink to the ground when the barometer reads low?

16. Why does a balloon rise?

FIG. 50*b*—Otto Von Guericke taught the people of his day something about the pressure of the atmosphere by making two hollow hemispheres which fitted nicely together and removing the air. It is said that all the horses available at the time the experiment was tried were unable to pull the hemispheres apart.

Aneroid or Corrected Barometer.	Height in Feet.	Aneroid or Corrected Barometer.	Height in Feet.	Aneroid or Corrected Barometer.	Height in Feet.	Aneroid or Corrected Barometer.	Height in Feet.	Aneroid or Corrected Barometer.	Height in Feet.
in.	ft.	in.	ft.	in.	ft.	in.	ft.	in.	ft.
31.00	0	28.28	2500	25.80	5000	23.54	7500	21.47	10,000
30.94	50	28.23	2550	25.75	5050	23.50	7550	21.44	10,050
30.88	100	28.18	2600	25.71	5100	23.45	7600	21.40	10,100
30.83	150	28.12	2650	25.66	5150	23.41	7650	21.36	10,150
30.77	200	28.07	2700	25.61	5200	23.37	7700	21.32	10,200
30.71	250	28.02	2750	25.56	5250	23.32	7750	21.28	10,250
30.66	300	27.97	2800	25.52	5300	23.28	7800	21.24	10,300
30.60	350	27.92	2850	25.47	5350	23.24	7850	21.20	10,350
30.54	400	27.87	2900	25.42	5400	23.20	7900	21.16	10,400
30.49	450	27.82	2950	25.38	5450	23.15	7950	21.12	10,450
30.43	500	27.76	3000	25.33	5500	23.11	8000	21.08	10,500
30.38	550	27.71	3050	25.28	5550	23.07	8050	21.05	10,550
30.32	600	27.66	3100	25.24	5600	23.03	8100	21.01	10,600
30.26	650	27.61	3150	25.19	5650	22.98	8150	20.97	10,650
30.21	700	27.56	3200	25.15	5700	22.94	8200	20.93	10,700
30.15	750	27.51	3250	25.10	5750	22.90	8250	20.89	10,750
30.10	800	27.46	3300	25.05	5800	22.86	8300	20.85	10,800
30.04	850	27.41	3350	25.01	5850	22.82	8350	20.82	10,850
29.99	900	27.36	3400	24.96	5900	22.77	8400	20.78	10,900
29.93	950	27.31	3450	24.92	5950	22.73	8450	20.74	10,950
29.88	1000	27.26	3500	24.87	6000	22.69	8500	20.70	11,000
29.82	1050	27.21	3550	24.82	6050	22.65	8550	20.66	11,050
29.77	1100	27.16	3600	24.78	6100	22.61	8600	20.63	11,100
29.71	1150	27.11	3650	24.73	6150	22.57	8650	20.59	11,150
29.66	1200	27.06	3700	24.69	6200	22.52	8700	20.55	11,200
29.61	1250	27.01	3750	24.64	6250	22.48	8750	20.51	11,250
29.55	1300	26.96	3800	24.60	6300	22.44	8800	20.47	11,300
29.50	1350	26.91	3850	24.55	6350	22.40	8850	20.44	11,350
29.44	1400	26.86	3900	24.51	6400	22.36	8900	20.40	11,400
29.39	1450	26.81	3950	24.46	6450	22.32	8950	20.36	11,450
29.34	1500	26.76	4000	24.42	6500	22.28	9000	20.32	11,500
29.28	1550	26.72	4050	24.37	6550	22.24	9050	20.29	11,550
29.23	1600	26.67	4100	24.33	6600	22.20	9100	20.25	11,600
29.17	1650	26.62	4150	24.28	6650	22.16	9150	20.21	11,650
29.12	1700	26.57	4200	24.24	6700	22.11	9200	20.18	11,700
29.07	1750	26.52	4250	24.20	6750	22.07	9250	20.14	11,750
29.01	1800	26.47	4300	24.15	6800	22.03	9300	20.10	11,800
28.96	1850	26.42	4350	24.11	6850	21.99	9350	20.07	11,850
28.91	1900	26.37	4400	24.06	6900	21.95	9400	20.03	11,900
28.86	1950	26.33	4450	24.02	6950	21.91	9450	19.99	11,950
28.80	2000	26.28	4500	23.97	7000	21.87	9500	19.95	12,000
28.75	2050	26.23	4550	23.93	7050	21.83	9550	19.241	13,000
28.70	2100	26.18	4600	23.89	7100	21.79	9600	18.548	14,000
28.64	2150	26.13	4650	23.84	7150	21.75	9650	17.880	15,000
28.59	2200	26.09	4700	23.80	7200	21.71	9700	17.235	16,000
28.54	2250	26.04	4750	23.76	7250	21.67	9750	16.615	17,000
28.49	2300	25.99	4800	23.71	7300	21.63	9800	16.016	18,000
28.43	2350	25.94	4850	23.67	7350	21.59	9850	15.439	19,000
28.38	2400	25.89	4900	23.62	7400	21.55	9900	14.883	20,000
28.33	2450	25.85	4950	23.58	7450	21.51	9950		

TEMPERATURE CORRECTIONS FOR ALTITUDE SCALES

Smithsonian Miscellaneous Collection No. 21.
For temperatures above 50° F. the values are to be added.
For temperatures below 50° F. the values are to be subtracted.

Temperature ° Fahr.		Feet of Altitude.					
		100	500	1000	2000	3000	4000
49	51	0	1	2	4	6	8
48	52	0	2	4	8	12	16
47	53	1	3	6	12	18	24
46	54	1	4	8	16	24	33
45	55	1	5	10	20	31	41
44	56	1	6	12	24	37	49
43	57	1	7	14	29	43	57
42	58	2	8	16	33	49	65
41	59	2	9	18	37	55	73
40	60	2	10	20	41	61	82
39	61	2	11	22	45	67	90
38	62	2	12	24	49	73	98
37	63	3	13	27	53	80	106
36	64	3	14	29	57	86	114
35	65	3	15	31	61	92	122
34	66	3	16	33	65	98	130
33	67	3	17	35	69	104	139
32	68	4	18	37	73	110	147
31	69	4	19	39	77	116	155
30	70	4	20	41	82	122	163
29	71	4	21	43	86	128	171
28	72	4	22	45	90	135	179
27	73	5	23	47	94	141	188
26	74	5	24	49	98	147	196
25	75	5	25	51	102	153	204
24	76	5	27	53	106	159	212
23	77	6	28	55	110	165	220
22	78	6	29	57	114	171	228
21	79	6	30	59	118	177	236
20	80	6	31	61	122	184	245
19	81	6	32	63	126	190	253
18	82	7	33	65	130	196	261
17	83	7	34	67	135	202	269
16	84	7	35	69	139	208	277
15	85	7	36	71	143	214	285
14	86	7	37	73	147	220	294
13	87	8	38	75	151	226	302
12	88	8	39	77	155	232	310
11	89	8	40	80	159	239	318
10	90	8	41	82	163	245	326
9	91	8	42	84	167	251	334
8	92	9	43	86	171	257	343
7	93	9	44	88	175	263	351
6	94	9	45	90	179	269	359
5	95	9	46	92	184	275	367
4	96	9	47	94	188	281	375
3	97	10	48	96	192	287	383
2	98	10	49	98	196	294	391
1	99	10	50	100	200	300	400
0	100	10	51	102	204	306	408

RESULTS OF CHANGING AIR PRESSURE

Effects of Temperature on Air Pressure.—Temperature affects the reading of the barometer. The air in a schoolroom 20 feet by 30 feet would weigh 903 pounds when the temperature is 60° F., but if the temperature were increased to 80° F. the air would expand, and some of it escape. The air left would weigh 873 pounds. Good barometers must be compensated for temperature, especially for measuring altitude.

The Air Pressure Varies for Different Kinds of Weather.—Torricelli observed, among other things, that the level of the mercury in the tube fluctuated as changes in the weather took place. When the air is heavy, the barometer reads high; and usually this occurs during fair weather. For example, 30.2 is a relatively high reading of barometer and 29 is a relatively low reading of barometer.

Sea Level.—An aneroid barometer for reading weather conditions must be corrected for altitude. Sea level means the reading of the barometer at an altitude, corrected in such a manner that it would

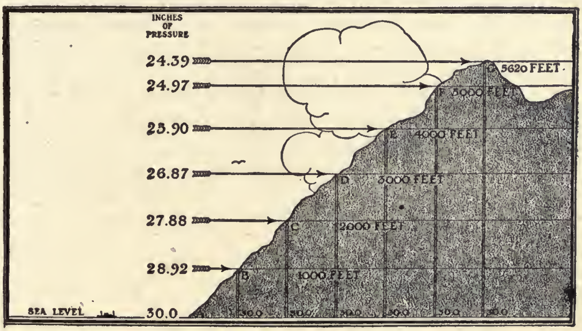


FIG. 51.—A diagram showing the relation between altitude and air pressure. Clobourg, Ill., Lowell, Neb., Spica, Kan., Kanarado, Kan., and Kanfield, Colo.

give a reading equal to the reading of the barometer if the place of observation were at sea level instead of at an elevation. The higher we go the less the pressure of air. By referring to the diagram, Fig. 51, air at sea level will be seen to have a pressure of 30 inches. At *B*, Clobourg, Ill., 1000 feet above sea level, the barom-

eter reads 28.92 inches. At *C*, Lowell, Neb., 2000 feet above sea level, it reads 27.88 inches. At *D*, Spica, Kansas, 3000 feet above sea level, it reads 26.87 inches. At *E*, Kanarado, Kansas, 4000 feet above sea level, it reads 25.9 inches. At *F*, Kanfield, Colo., 5000 feet above sea level, the barometer reads 24.97 inches.

Fig. 52.—An aneroid barometer.

The pressure at sea level is not stationary. The barometer has been known to vary from 31.7 inches to 26.96 inches, but its average movement is from 28.4 inches to 30.3 inches. The United States Weather Bureau requires that all barometers be corrected for sea level; for example, if the barometer is reading 30 inches at sea level, the corresponding reading at Kanfield, Colo., would be 24.97 inches, but the Chief Forecaster at Washington must have the reading of the barometer which would represent the reading if Kanfield, Colo., were at sea level; consequently each reading is reduced to sea level.

Instead of telegraphing to Washington 24.97 inches for Kanfield, or 26.87 inches for Spica, the local forecaster of each place would send 30 inches as the reading of his barometer.

Corrections for Elevations above Sea Level.—If altitude is

250 feet add	0.29 inches to barometer reading.
500	0.57
750	0.85
1000	1.12
1250	1.39
1500	1.66
1750	1.93
2000	2.20
2500	2.72
3000	3.24
3500	3.74
4000	4.24
4500	4.72
5000	5.20

How to "Set" Barometers.—If the observer is situated at any point above sea level, the barometer, unless corrected, will read lower than the reading at sea level, on account of the lessened pressure due to altitude.

After finding the altitude, and determining the difference, the indicating hand of the barometer should be lifted off the pin on which it is fitted and replaced at the corrected reading.

Never make this change by means of the small screw seen in the back.

Effect of Different Pressures of the Air.—The different pressures of the atmosphere produce movements of the air. Suppose the atmosphere in our schoolroom (effects of temperature on the barometer) is heated to 80° F. The air would now weigh 873 pounds; but suppose the air outside was 60° F. A volume of outside air equal to the volume of air in the schoolroom would weigh about 933 pounds or 60 pounds more than the air in the schoolroom. Every cubic foot of air outside would weigh $\frac{1}{10}$ of a pound more than every cubic foot inside. This extra weight of air would press on the windows and walls, trying to get into the room. If you should hold your hand near the window you would feel the air rushing in at the places where it does not fit tightly. If you open the window you feel the breeze blowing in.

Ventilation.—The difference in pressure of the air assists us to ventilate our houses. The heavy outside air is allowed to rush in and push out the light, warm air which has become bad. The proper ventilation of rooms is very important. The diagram on page 179 will show the effects of poor ways and good ways of ventilating our schoolrooms, as well as our homes.

Soil Ventilation.—The constantly changing pressure of the atmosphere ventilates the soil. When the pressure is great, large quantities of air are forced among the soil particles. As the atmospheric pressure becomes less, the air expands and a part of it is forced out of the ground.

Drafts.—If we hold a piece of joss stick near the draft of a stove, we will see the smoke rushing toward the opening. The air in the stove is heated, and is much lighter than the air outside of the stove. There is a great pressure caused by the cooler air outside which presses the hot air and smoke up the chimney. More will be said about the use of the difference in air pressure when we study methods of heating and ventilating our homes.

Winds.—Make a small pin-wheel and hold it over a Bunsen burner or a kerosene lamp, high enough so it will not burn. The rising air currents will cause the pin-wheel to turn. The heated air may be observed rising if the light is between you and the window. Often, heated air may be discerned rising over radiators and stoves. If the lamp is very large, smoke from a joss stick held on the side near the bottom will show that cold air is rushing in and pushing the heated air up. As this heated air rises it takes a counter clockwise spiral form much like the way we see water running out of a sink at home.

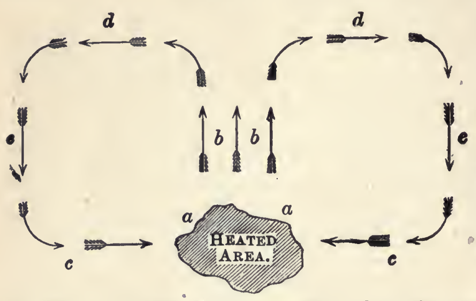


FIG. 53*a*.—Origin of winds. Why does the air at *b*, *b* rise? Why does the air at *e*, *e* fall? Why does the air at *c*, *c* move toward the heated area?

If you could see the air as you can see water it would seem like the Whirlpool Rapids of Niagara—all swirls, pockets, vortexes and curling eddies. The inclined rock bottom of the Niagara below the falls makes the Whirlpool Rapids what they are. But the vortexes and currents of the air are due to the constant efforts of the atmosphere to find its temperature level.

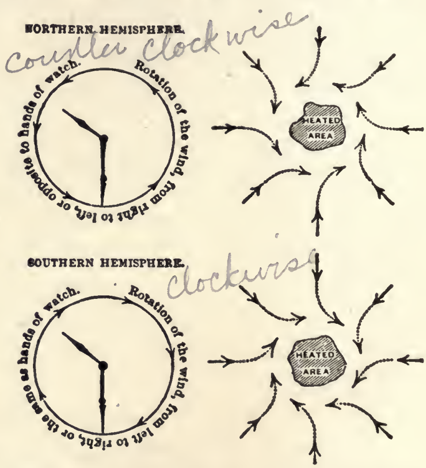
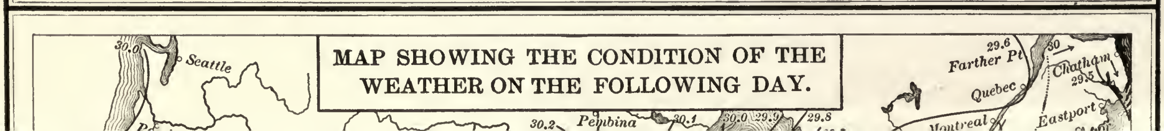


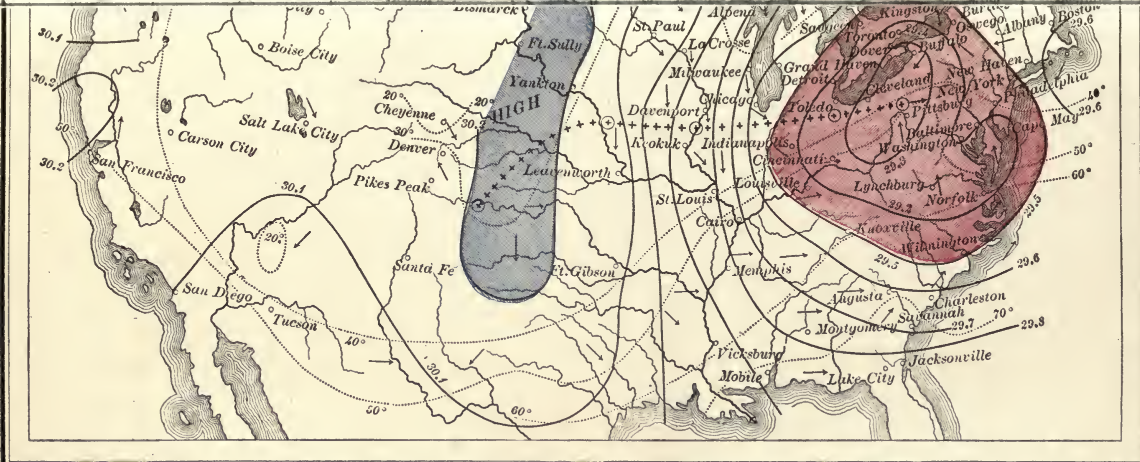
FIG. 53*b*.—Cause of the rotation of the wind.

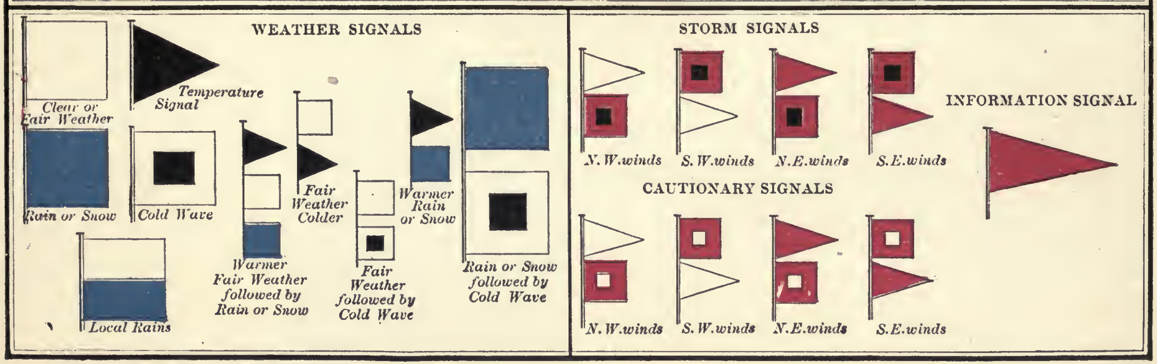
Lows and Cyclones.—Suppose the barometer reads lower in Indiana than in any of the surrounding states. Naturally, air from the northern, southern, eastern and western parts of the country would rush in, pushing the lighter air over Indiana upward. Even a small difference in the reading of the barometer would

WEATHER MAP, SHOWING CONDITION OF THE WEATHER ON A CERTAIN DAY IN APRIL.



MAP SHOWING THE CONDITION OF THE WEATHER ON THE FOLLOWING DAY.


HIGH
Boise City
Salt Lake City
Carson City
San Francisco
Cheyenne
Denver
Pikes Peak
Santa Fe
San Diego
Tucson
Ft. Sully
Yankton
Leavenworth
Ft. Gibson
St. Paul
La Crosse
Milwaukee
Chicago
Davenport
Keokuk
Indianapolis
Cincinnati
Louisville
St. Louis
Cairo
Memphis
Vicksburg
Mobile
Lake City
Jacksonville
Montgomery
Augusta
Savannah
Charleston
Wilmington
Knoxville
Lynchburg
Norfolk
Washington
Baltimore
Pittsburg
Toledo
Cleveland
Detroit
Grand Haven
Alpena
Saugeen
Toronto
Kingston
Oswego
Buffalo
Albany
Boston
New Haven
New York
Philadelphia
Cape May
30.1
30.2
29.5
29.6
29.7
29.8
20°
30°
40°
50°
60°
70°


WEATHER SIGNALS
Clear or Fair Weather
Temperature Signal
Rain or Snow
Cold Wave
Local Rains
Warmer Fair Weather followed by Rain or Snow
Fair Weather Colder
Fair Weather followed by Cold Wave
Warmer Rain or Snow
Rain or Snow followed by Cold Wave
STORM SIGNALS
N. W. winds
S. W. winds
N. E. winds
S. E. winds
CAUTIONARY SIGNALS
N. W. winds
S. W. winds
N. E. winds
S. E. winds
INFORMATION SIGNAL

mean great pressure. Every inch of mercury pressure (on barometer) is equal to about .49 pound per square inch, so that in the diagram weather map, next page, the difference in the pressure between Florida and Ohio would be about ½ pound per square inch or more than 1,000,000 tons per square mile. Between what other places would there be such pressure? Suppose the difference in pressure was only .5 of an inch, 2 inches, 1 inch?

How much difference in the pressure per square foot would there be between places having a difference of 2 inches mercury pressure? How many pounds per square mile?

These great eddies or swirls in the atmosphere are known as "cyclones" and "anticyclones." The eddies, hundreds of miles in diameter, move eastward bodily across the country at an average speed of something like 500 to 1000 miles a day. While they are near us, we generally have strong winds; as they move away, the winds subside. Cyclonic areas are those in which the air moves around toward a region of low pressure. Anticyclonic areas are areas in which the air moves outward from a region of high pressure. (Refer to diagram.) In our latitudes cyclones and anticyclones succeed each other every two or three days.

FIG. 54.—Photograph of a distant tornado.

How the Cyclones Affect the Direction of Local Winds.—The wind in Michigan will blow toward the low area which is marked on the weather map, Fig. 54*a* and *b* as a low. This wind would be called the north wind. Florida would get a southeast wind. New Jersey would get an east wind.

If the low passed south of New Jersey the people of that State would get a northeast wind. If the low went north of the State, a southeast wind would blow, shifting as the low moved.

How Low Affects Weather.—As the winds come in from over

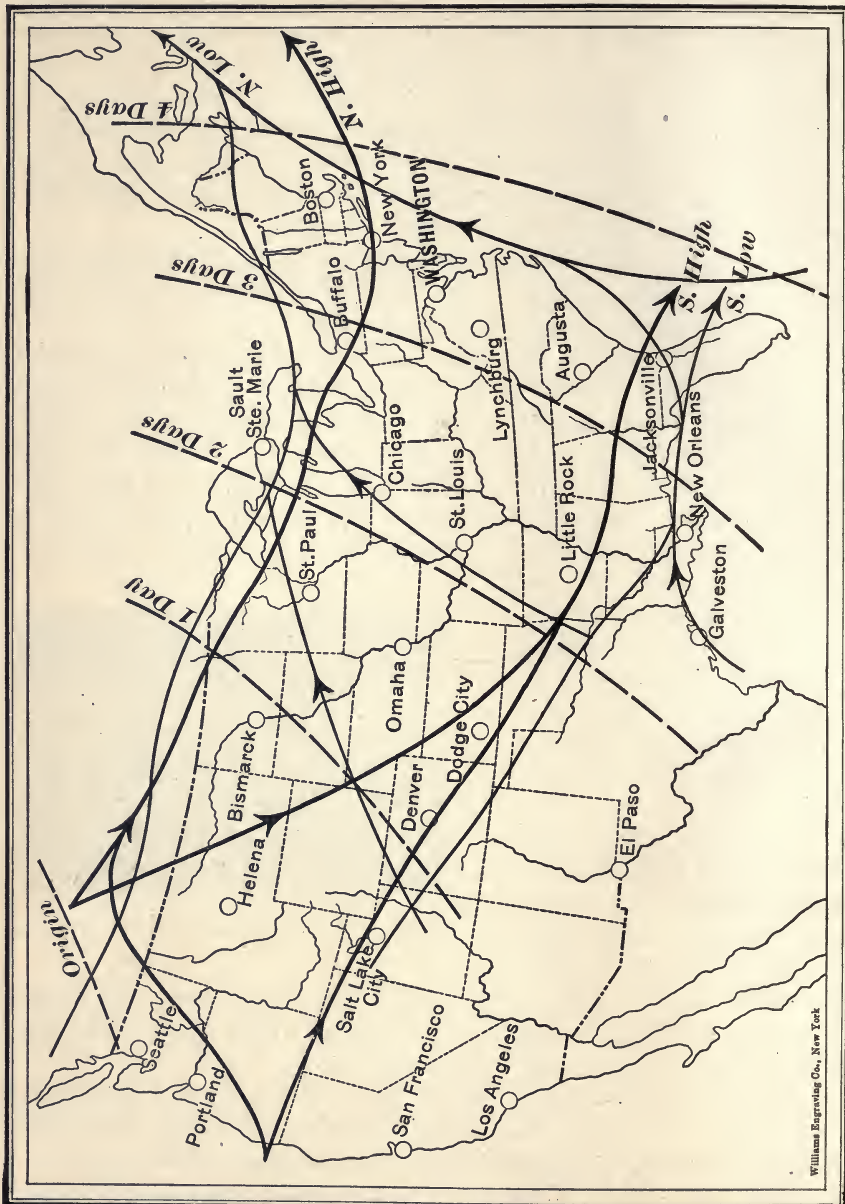


Fig. 55.—A map showing the movement of storms across the United States.

large bodies of water, a great deal of moisture is absorbed by the air. On the Atlantic Coast it is easy to see that easterly winds bring rain, while westerly winds bring fair weather.

The low over New Jersey shows how the air rushing in from over the ocean, laden with water vapor, rises and mixes with the colder air. The moist air in turn cools off, and is forced to drop its moisture as rain.

Find other parts of the country which would look for storm winds from different points of the compass.

How to Tell the Velocity of the Wind.—The tables are given below to determine the velocity of the wind.

Force.	Designation.	Miles per Hour.	Average Pressure in Pounds per Square Foot.	Effect.
0	Calm.........	0 to 3	.01	No movement of leaves or smoke.
1	Light air......	3 to 8	.25	Slight movement of leaves and smoke turned from vertical.
2	Light breeze...	8 to 13	.5	Moves small branches.
3	Gentle breeze..	13 to 18	1.4	Blows up dust, moves the medium-sized branches.
4	Moderate breeze.......	18 to 23	2.5	Moves large branches.
5	Fresh breeze . .	23 to 28	3	Sways trees.
6	Strong breeze..	28 to 34	5	Sways trees and breaks small branches.
7	Moderate gale.	34 to 40	7	Bends small trees over.
8	Fresh gale....	40 to 48	10	Breaks small trees down.
9	Strong gale....	48 to 56	15	Breaks off large branches.
10	Whole gale....	56 to 65	19	Blows off bricks from exposed chimneys, and shingles from roofs.
11	Storm........	65 to 75	26	Uproots trees, blows down frail houses.
12	Hurricane.....	Over 75	31	Prostrates everything.

Wind blowing over 100 miles per hour would have a pressure of over 50 pounds per square foot.

To determine the pressure of the air current, multiply the square of the velocity of the air in feet per second by .0023.

This scale is sometimes used:

Name.	Miles per Hour.	Apparent Effect.
Calm.......	0	No visible horizontal motion to inanimate matter.
Light.......	1 to 2	Causes smoke to move from the vertical.
Gentle......	3 to 5	Moves leaves on trees.
Fresh.......	6 to 14	Moves small branches of trees and blows up dust.
Brisk.......	15 to 24	Good sailing breeze, makes whitecaps.
High........	25 to 39	Sways trees and breaks small branches.
Gale........	40 to 59	Dangerous for sailing vessels.
Storm.......	60 to 79	Prostrates exposed trees and frail houses.
Hurricane...	80 upwards	Prostrates everything.

STANDARD TABLE

Description.	Miles per Hr.	Ft. per Min.	Ft. per Sec.	Force in Lbs. per Sq. Ft.	Pressure in Lbs. per Sq. Ft.
Scarcely perceptible	1	88	1.47	.005	.0049
Just perceptible...	2	176	2.93	.020	.0195
	3	264	4.4	.044	.0460
Gentle breeze.....	4	352	5.87	.079	.0807
	5	440	7.33	.123	.1251
Pleasant breeze ...	10	880	14.67	.492	.4957
	15	1320	22.0	1.107	1.1184
Brisk gale........	20	1760	29.3	1.968	2.0095
	25	2200	36.6	3.075	3.1153
High wind........	30	2640	44.0	4.428	4.6618
	35	3080	51.3	6.027	6.0700
Very high wind ...	40	3520	58.6	7.872	7.9195
	45	3960	66.0	9.963	9.9875
Storm............	50	4400	73.3	12.300	12.3802
Great storm......	60	5280	88.0	17.712	17.8189
	70	6160	102.7	24.108	24.2594
Hurricane........	80	7040	117.3	31.488	31.6700
	100	8800	146.6	49.200	49.4854

1. Why does smoke from a chimney fall toward the ground before a storm?

2. Why is air full of water vapor lighter than dry air?

3. About how much force would a storm wind exert on you?

4. How high will water rise in a pump? Why?

5. If water will rise only about 30 feet in a pump, how is it possible to get water from a well which has been drilled to the depth of 100 feet?

6. Is smoke pushed or pulled up a chimney?

7. Why do balloons rise? When will a balloon stop rising?

8. Why will a fireplace or stove smoke when the fire is first started?

9. How could the smoking be prevented?

10. What is meant by a draft in a chimney?

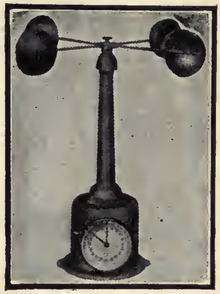


FIG. 56.—An anemometer. What is the meaning of anemometer?

11. Why do tall chimneys have a better draft than short chimneys?

12. What is the best way to air out a room?

WINDS AND WEATHER

Isobars and Isotherms.—The different stations send to Washington each day their reading of the barometer. Lines called isobars are drawn through the places where the barometric pressures are the same. If the lines are close together there is a great difference of pressure. Such a low is accompanied by a great deal of wind. If the lines are far apart the opposite is true. Sometimes such lows die out entirely. At other times they develop into vigorous storms. These irregularities are rare, but when they do happen, they, of course, upset the weather forecast. The lows travel on the average from 500 to 1000 miles per day.

The heavy lines are called isotherms. They run through places of equal temperatures.

Floor or Wall Weather Maps.—A very helpful way to study the weather conditions is to have a map made of linoleum large enough to place on the floor. Such floor maps may be purchased for a small amount. Round discs

with concentric circles may be used for lows and highs. Black discs with white circles represent the highs, and white discs with black circles the lows. If five minutes of each period are used to arrange the discs according to the weather map, predictions may be easily made.

There should be three kinds of discs, some with the isobars close together, some far apart, and some of medium separation. There should also be discs

High, much Wind. Low, little wind. Low, with wind. Low, much wind.

Fig. 57.—A floor map for weather prediction. The low with light lines shows where the low with the dark lines was the day before. All the highs and lows for to-day and the day before should be placed on the floor map each day according to the U. S. Weather Map. The action of highs and lows according to direction and speed may be easily studied.

marked "Yesterday" which should be placed on the map at the same time to show the direction and distance the high or low traveled from one day to the next.

Another method is to use the map on the wall as a bulletin board. This is not satisfactory, as it is not placed in true directions, north and south.

Directions of Winds.—When the wind sets in from points between south and southeast, and the barometer falls steadily, a

storm is approaching from the west or northwest; and its center will pass near or to the north of the observer within twelve to twenty-four hours, with winds shifting to northwest, by way of southwest and west. Place a round disc on the map northwest of your State. Air is blowing in toward the center of the disc; or a low is passing over your State from the southeast toward the northwest.

When the wind sets in from points between east and northeast, and the barometer falls steadily, a storm is approaching from the south and southwest, and its center will pass near to the south of the observer within twelve or twenty-four hours, with winds shifting to northwest by way of north. The rapidity of the storm's approach, and its intensity, will be indicated by the rate and the amount of the fall in the barometer.

General Indications.

BAROMETER RISING

1. A gradual but steady rise indicates settled fair weather.

2. A very slow rise from a low point is usually associated with high winds and dry weather.

3. A rapid rise indicates clear weather and high winds. The barometer rises for northerly wind (including from northwest, by the *north*, to eastward), for dry or less wet weather, for less wind, or more than one of these changes—except on a few occasions when rain, hail or snow comes from the northward with *strong* wind.

BAROMETER FALLING

4. A gradual but steady fall indicates unsettled or wet weather.

5. A very slow fall from a high point is usually connected with wet and unpleasant weather, without much wind.

6. A sudden fall indicates a sudden shower, or high winds, or both.

The barometer falls for southerly wind (including from southeast by the *south* to the westward), for wet weather, for stronger wind, or for more than one of these changes—except on few occasions when *moderate* wind with rain (or snow) comes from the northward.

"Veering" wind is a wind that moves from left to right; i.e., "clockwise."

If the wind shifts the opposite way, the change is called "backing," indicating the approach of another storm.

"When the wind veers against the sun,
Trust it not, for back 'twill run."

Weather Forecast.

Barometer Reading.	For Falling Barometer	For Rising Barometer
30.8–31	Continued cool, warmer and cloudy to-morrow.	Southeast rains with high winds.
30.5–30.8	Fair and warmer, followed by wind and rain.	Clear to-night, and continued cool with moderate winds.
30.2–30.5	Storm brewing in the direction of the wind.	Generally fair, probably cool to-day, with variable winds.
29.9–30.2	Cloudy and warmer, followed by unsettled.	Fair, with brisk winds, which will diminish.
29.6–29.9	Unsettled, increasing winds and warmer.	Fair, with fresh winds to-night and to-morrow.
29.3–29.6	Clearing, slight squall, fair and cooler to-morrow.	High winds, with cool wave, preceded by squall.
29.0–29.3	Clearing, with high wind, accompanied by squalls and cooler.	Clearing, with high winds and cool wave.
28.7–29	Stormy.	Increasing winds followed by colder weather.
28.4–28.7	Very stormy.	

EFFECT OF TEMPERATURE ON THE WEATHER

Barometer Rising

Below 30° F..................	Cold wave.
Between 30° and 40° F.......	Freezing.
Between 40° and 50° F.......	Probable frost.
Between 50° and 60° F.......	Cooler.
Above 60° F..................	Warm with cool nights.

Barometer Falling

Below 30° F..................	Snow storm.
Between 30° and 40° F.......	Rain or snow.
Between 40° and 50° F.......	Rain storm.
Between 50° and 60° F.......	Heavy rains.
Above 60° F..................	Showers.

WINDS

Barometer Rising

S. to S.W. Barometer 30.0 inches, or below, and rising slowly.	Clearing within a few hours, and continued fair for next few days.
S.W. to N.W. Barometer 30.10 to 30.20 inches, steady.	Fair, with slight temperature changes.
S.W. to N.W. Barometer 30.10 to 30.20 inches, rising rapidly.	Fair, followed within forty-eight hours with warmer and rain.
Going to W. Barometer 29.80 inches, or below, and rising rapidly.	Clearing and colder.
Between N. and E. Barometer rising.	Weather turning cooler.
Between S.W. and S. Barometer rising.	Weather probably warmer to-morrow, but cloudy.

WINDS

Barometer Falling

S. to E. Barometer 29.8 inches and below and falling rapidly.	Severe storm of rain (in summer) or snow (in winter) imminent, clearing and colder in 24 hours.
S. to S.E. Barometer 30.1 to 30.2 inches, falling rapidly.	Rain in 18 to 24 hours.
S. to S.E. Barometer 30.1 to 30.2 inches, falling slowly.	Rain in about 24 hours.
E. to N.E. Barometer 30.10 and above and falling slowly (winter).	Rain or snow within 24 hours.
E. to N.E. Barometer 30.10 and above and falling slowly (summer).	With light winds; rain may not fall for several days.
E. to N.E. Barometer 30.10 inches and above and falling rapidly (summer).	Rain probable within 12 to 24 hours.

E. to N.E. Barometer 30.10 and above and falling rapidly (winter).	Rain or snow, with increasing wind, especially if wind is from N.E.
S.W. to N.W. Barometer above 30.2 inches and falling slowly.	Slowly rising temperature and fair for 48 hours.
S.W. to N.W. Barometer 30.1 to 30.2 inches and falling rapidly.	Warmer, with rain in from 18 to 24 hours.
S.W. to N.W. Barometer 30.1 to 30.2 inches and falling slowly.	Warmer, with rain in from 24 to 36 hours.
S.E. to N.E. 30 and below and falling rapidly.	Rain, with high winds, followed in 24 hours by clearing and cooler.
S.E. to N.E. 30 and below and falling slowly.	Rain for one or two days.
E. to N. Barometer 29.8 or below, falling rapidly.	Severe N.E. gales and heavy rains or snow, followed in winter by cold wave.
S.E. to S.W. With barometer falling.	Storm coming from W. or N.W., followed by cooler and W. to N.W. winds.
N. and E. With barometer falling.	Storm coming from S. or S.W., followed by cooler and N. to N.W. winds.

World Winds.—The air at the equator becomes heated and rises, while cold air from the north blows toward the equator to take the place of the rising air. The air moving from the north will become heated and begin to rise near latitude 30 degrees, joining the warm air coming up from the equator on its way to the north. A part of the air coming up from the equator will become cold, and flow downward, joining the cold air going toward the equator at latitude 30°.

These places on the earth's surface are called "horse latitudes."

Here air has an upward and downward movement, and there is no steady horizontal wind. The term horse latitude was applied by sailors in the days of sailing vessels which carried horses from New England to the West Indies.

Vessels were delayed by calms for a long time, fresh water would give out and the sailors would be forced to throw the horses overboard.

Belts of Calms.—At the equator warm air is continually rising and cold air falling. There is no current of air blowing horizontally.

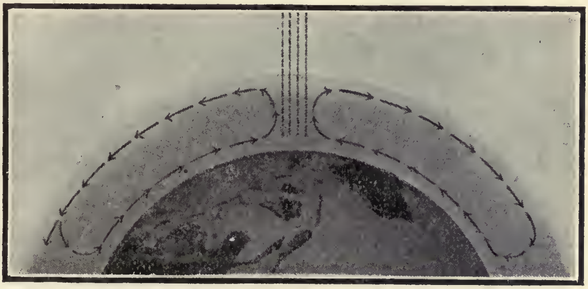


FIG. 58.—A place on the Earth's surface where Air is rising.

Such a condition causes a region of calms about 100 miles on each side of the equator. Why was this so troublesome to sailors years ago? Why are not sea captains annoyed with the belt of calms to-day?

Trade Winds.—The air flowing toward the equator causes very steady winds, called trade winds. Winds blowing from the equator are called anti-trade winds. As air approaches the equator, it becomes warmer and, of course, holds more moisture. For this reason the trade wind area is known as the clear-weather belt.

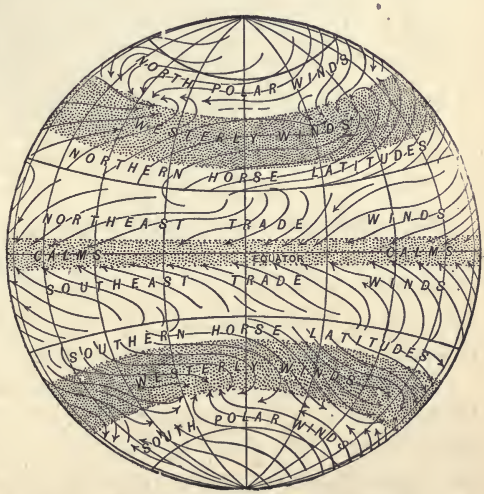


FIG. 59.—The wind belts on the rotating earth.

The Prevailing Westerlies.—Between the horse latitudes and the equator the winds take a westerly direction because

of the rotation of the earth. Pour a small amount of water at the north end of a revolving globe. The rotation of the globe causes the water to run in a stream in a westerly direction above the equator, and easterly below the equator.

FIG. 60.—The wind systems of the world.

Sea Breezes and Land Breezes.—During the day the earth becomes warmer than the water. The air over the earth rises, while the cooler air from over the ocean rushes in toward the land, causing sea breezes. At night the opposite condition is true, as the land cools off much faster than the water.

Monsoons.—Monsoons are winds which blow from the Indian Ocean to the heated lands toward the Himalaya mountains. Such winds blow from May to October. During the remaining part of the year the land is cooler than the water and the wind blows toward the ocean.

Tornadoes.—Tornadoes are immense whirlwinds which are caused by overheated conditions. They are preceded by the formation of

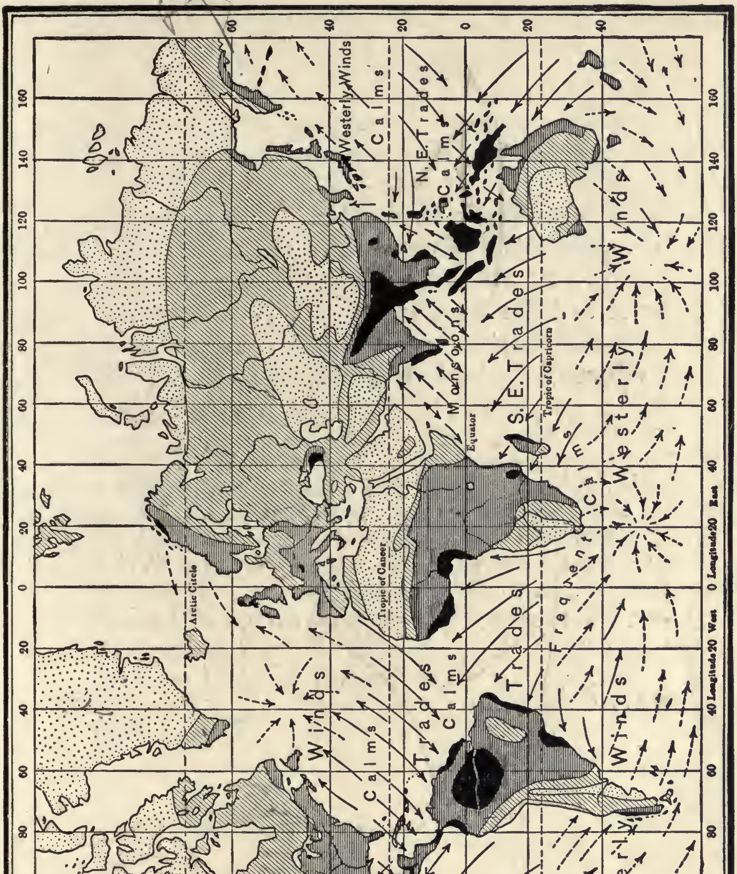


FIG. 61.—Winds of the World.

an inverted cone cloud mass. The funnel shape is due to the rotation of the winds around a central point.

The influence of tornadoes is felt only over limited areas, but the high wind velocity, sometimes exceeding 100 miles an hour, and the extremely low barometric pressures that attend them make them very destructive.

Why a Kite Remains Up in the Air. A kite remaining high in the air is an example of the pressure of the atmosphere in motion. In flying a kite a boy will run against the wind in order to make enough pressure to force the kite upward, since near the earth the trees, buildings and hills interfere with a constant pressure of the atmospheric current in a horizontal direction. After the kite has risen to a height, above the objects which interfere with the wind, it will remain in about the same position.

Experiment for Studying the Pressure of the Upper Current.—Some idea of the pressure of the moving air current may be obtained by flying a kite which has a known number of square feet of surface. Attach a spring balance to the end of the string. Make a series of readings for 10 or 15 minutes, noting whether the pressure of this current remains constant.

What is the pressure per square foot on the surface of the kite?

Questions

1. Fill a sink or hand basin with water. Place a piece of wood, or any material which will float, on the surface of the water. Pull the stopper.

Which way does the water run out of the sink or basin? Clockwise or counter-clockwise? Does it run in the same direction every time you try it? Why does the water take a spiral motion? Which way would the water run out in the southern hemisphere?

2. If a low is in Iowa, which way will the wind blow in North Dakota, Indiana, Kansas, Wisconsin?

3. Why is there always a wind near a large fire?

4. What winds bring rain to your section of the country?

5. Why do people at the center of a low feel no wind blowing?

6. Why does the barometer drop as a low approachcs?

7. How are we able to determine whether the low will pass directly over us, south of us, north of us?

8. Why are cyclones called lows?
9. Why are anticyclones called highs?
10. Why does a kite remain in the air?

OBSERVATIONS AND PREDICTIONS OF THE WEATHER

Weather Signals.—The following weather signals are used by the United States Weather Bureau, Department of Agriculture.

A white flag, 72 inches by 72 inches, alone, indicates fair weather.

A blue flag, 72 inches by 72 inches, alone, indicates rain or snow.

A blue and white flag (white part 72 inches by 36 inches, blue part 72 inches by 36 inches) indicates local rain or snow.

A white flag with a black center (white part 72 inches by 72 inches, black part in center 24 inches by 24 inches) indicates cold wave.

A black triangular flag, 45 inches at the base and 72 inches long, is used to denote temperature.

A white flag, with a black triangular flag above it, indicates fair and warmer.

A white flag, with a black triangular flag below it, indicates fair and colder.

A blue flag, with a black triangular flag above it, indicates rain or snow, and warmer.

A blue flag, with a black triangular flag below it, indicates rain or snow, and colder.

A blue and white flag, with a triangular black flag above it, indicates local rain or snow, and warmer.

A blue and white flag, with a triangular black flag below it, indicates local rain or snow, and colder.

The following signal flags are used for small craft, storm and hurricane warnings.

Small Craft Warning.—A red pennant indicates that moderately strong winds are expected.

Storm Warning.—A red flag with a black center indicates that a storm of marked violence is expected.

The pennants displayed with the flags indicate the direction of the wind: white, westerly (from southwest to north); red, easterly (from northeast to south). The pennant above the flag indicates

that the wind is expected to blow from the northerly quadrants; below, from the southerly quadrants.

By night, a red light indicates easterly winds, and a white light below a red light, westerly winds.

Hurricane Warning.—Two red flags with black centers, displayed one above the other, indicate the expected approach of a tropical hurricane, or one of those extremely severe and dangerous storms which occasionally move across the lakes and northern Atlantic coast.

No night small craft or hurricane warnings are displayed.

Recording the Amount of Cloudiness.—If the sky is $\frac{3}{10}$ or less covered with clouds, the day is called clear; $\frac{4}{10}$ to $\frac{7}{10}$, partly clouded; $\frac{8}{10}$ and over, cloudy.

FIG. 62.—A set of weather instruments which prove very helpful in the study of weather conditions.

WEATHER CHART

Date.	Hour.	Barometer.		Wind.		Clouds.		Precipitation.		Humidity.	Special Observations.	Probabilities.	Weather Flags.
		Reading.	Falling or Rising.	Direction.	Velocity.	Kind.	Amount.	Kind.	Amount.				

During the course keep observations on the weather in the above tabulated form.

PREDICTION OF WEATHER BY SPECIAL OBSERVATIONS

Special Observation.—The following material is often used by people to roughly forecast weather. This should be studied to determine whether any of the sayings are fallacies.

"Halo" around the moon. The smoke falling toward the ground. (Indication of storm, as the barometer is reading low, and the atmosphere full of water vapor is lighter than the smoke. Dry air is heavier than air full of water vapor.)

To Predict Weather by the Clouds.

Soft-looking or delicate clouds foretell fine weather.

Small black clouds foretell rain.

To Predict Weather by the Sky.

A bright blue sky indicates fair weather.

Yellow sky at sunset, wind.

Pale yellow, rain.

Dark, gloomy, blue sky, light wind.

Dark, oily looking clouds, wind.

Rosy sky at sunset, fine weather.

Sickly looking green hue, wind and rain.

Streaks in the sky, often miscalled "the sun drawing water," foretell rain. The sun is shining through an excess of moisture in the sky, between the clouds.

Rainbow in the afternoon, fair weather.

A dark red sky, rain.

A red sky in the morning, wind and rain.

Gray sky in the morning, fair weather.

Remarkable clearness of the atmosphere near the horizon, distant objects, hills, islands raised or unusually visible; and what is called a good hearing day, foretell rain and wind. This condition is called a "land loom" by fishermen, who usually prepare at once for a storm.

After fine weather, the first signs in the sky of a coming change are usually light streaks, curls, wisps, or mottled patches of distant white clouds which increase, and are followed by an overcasting of murky vapor that grows into cloudiness. The appearance indicates wind and rain, and may be observed in the atmosphere sometimes two or three days before a storm.

If the sun before setting appears diffused and of a brilliant white, it foretells storm.

If it sets in a sky slightly purple, the atmosphere near the zenith being of a bright blue, we may look for fine weather.

Above the rest, the sun who never lies,
Foretells the change of weather in the skies;
For if he rise, unwilling, to his race,
Clouds on his brow and spots upon his face,
Or if through mist he shoots his sullen beams,
Frugal of light, in loose and straggling streams,
Suspect a drizzling day and southern rain,
Fatal to fruits, and flocks and promised grain.

Dew and fog indicate fine weather.

"Evening red and morning gray; two sure signs of one fine day."

Weather Lore

"When the wind veers against the sun,
Trust it not, for back 'twill run."

"When the wind is in the east,
'Tis good for neither man or beast."

"If hoar-frost comes on mornings twain,
The third day surely will have rain."

"If clouds look as if scratched by a hen,
Get ready to reef your topsails then."

"Mackerel sky, mackerel sky,
Not long wet, nor yet long dry."

"If the sun goes pale to bed,
'Twill rain to-morrow, it is said."

"Long foretold, long last,
Short notice, soon past."

"Evening red and morning gray,
Help the traveler on his way."

"When the glass falls low, prepare for a blow,
When it rises high, let all your kites fly."

"An evening gray and morning red,
Will send the shepherd wet to bed."

"Mackerel sky and mare's tails,
Make lofty ships carry low sails."

Other Signs.—Spiders are very sensitive to atmospheric changes. Every twenty-four hours the spider makes some alteration in its web to suit the weather. When a high wind or heavy rain threatens, the spider may be seen taking in sail, shortening the rope filaments that sustain the web structure. If the storm is to be unusually severe or of long duration, the ropes are strengthened, as well as shortened.

On the contrary, when you see the spider lengthening the slender filaments, it is certain that calm, fine weather has set in, the duration of which may be measured by their elongation. When the spider sits quiet and dull in the middle of its web, rain is not far off. If it be active, however, and continues so during a shower, the rain will be of brief duration, and sunshine wil follow. When you see the spiders coming out of the walls more freely thar usual, you may be sure that rain is near.

Leech Barometer.—If there is an aquarium in the school room the following material will be found an interesting addition to this work.

Leeches are exceedingly sensitive to weather changes. Fill a jar with pure water and cover the opening with muslin, after placing a leech inside. During fine weather the leech lies motionless at the bottom of the jar. When rain is coming, it climbs to the upper part and seems generally unsettled. At the coming of wind or thunder, it becomes extraordinarily active, moving rapidly about and scarcely staying in one place for ten seconds.

Frog Barometer.—The same kind of a jar that was used for the leech may be used for the frog barometer. In this case a small wooden ladder should be used, and the water in the jar should not come beyond the third step. When the weather is likely to be fine and dry, the frog remains below the water most of the time. At the approach of rain it climbs up the ladder, and sits entirely out of the water; as the weather becomes clear, it returns to the water. In both barometers, change the water at least once a week.

Questions

1. What are some of the signs of approaching rain?

2. How are people who are troubled with rheumatism or neuralgia affected by the weather?

3. What weather flags would you use to-day?

Questions for Investigation

1. How are you physically conscious of an approaching storm? What conditions of the air make you feel the approaching storm? How long before the arrival of a storm are you able to predict its approach?

2. From what directions does the wind usually blow before a

storm? From what directions does the wind usually blow after a storm?

3. Compare the velocity of the wind just before, during and after a storm.

4. Compare the temperature before, after and during a storm.

5. Just before a storm, is the sky more or less cloudy?

6. How does the sky look after a storm?

BOILING POINT

Atmospheric Pressure Affects the Rate of Evaporation.—Water evaporates more rapidly in high places, where the atmospheric pressure is low, than in valleys.

Effect of Air Pressure on the Boiling of Water.—The pressure of the atmosphere causes a difference in the temperature at which water boils. At sea level if we fill a flask half full of water and apply heat, the water will not begin to boil until it has reached a temperature of about 212° F.; but if we happen to live in Denver, Colo., the water will boil at about 203° F. because Denver is over 5000 feet above sea level, and the air pressure is not so great. An ascent of about 596 feet produces a difference of 1° F.

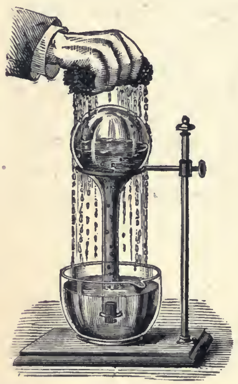


Fig. 63.—The water in the flask will boil more vigorously if ice is used in place of cold water and sponge.

Water while boiling is violently agitated by steam bubbles which are formed at the bottom of the flask, nearest the flame. The steam bubbles rise and burst, sending off steam with a pressure greater than that of the air. In other words, the pressure of steam at sea level must be over 14.7 pounds per square inch, and in Denver 11.4 per square inch.

Remove the flame from under the flask, quickly close it with a rubber stopper and invert the flask on a ring stand. While the water was boiling, the steam forced out all the air, leaving in the flask nothing but steam and water. The pressure of the steam keeps the water

from boiling. Place a piece of ice on the bottom of the flask. As the ice melts, and cold water runs down over the flask, steam condenses, and reduces the pressure on the surface of the water. Since water boils more easily at a low pressure than at high pressure, the water begins to boil immediately. Why does the water stop boiling every time the ice is removed?

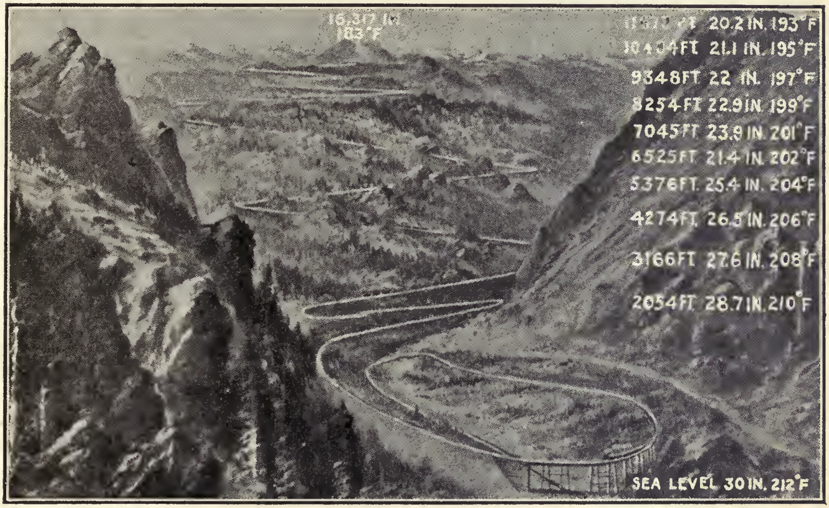


FIG. 64.—How hot would boiling water be on Pike's Peak? In Denver, Colo.? In Spica, Kan.? In Kanfield, Colo.? In New York?—the barometer reading 30 inches at sea level. How is it possible for an aeronaut to tell how high he is above the ground with a barometer? Why could Mark Twain tell how high up in the Alps he was by "boiling his thermometer"?

Boiling point varies about .88 of a degree Fahrenheit for a variation in the barometer of half an inch. Water boils in a practical vacuum, or when the mercury has fallen to .24 of an inch (0.1176 pound pressure), at about 40° F. which is the lowest temperature at which water will boil.

At the top of Mt. Blanc in Switzerland, which is three miles high, water boils at 185° F. A traveler could not boil eggs at the top of this mountain, as the white of an egg will not harden unless the temperature is far in excess of 185° F.

"Singing" of a Teakettle.—When water is first heated, tiny bubbles of air, which was dissolved in the water, pass off. Steam bubbles next appear on the sides and bottom of the flask. They rise a short distance and condense, since the water is not as hot as the bubbles of steam. This often causes a noise which is known as the "singing of a teakettle."

Fig. 65.—Denver Cooker.

Pressure Cooker.—The pressure cooker is designed to cook at 20 pounds of steam pressure in addition to the atmospheric pressure. Water will boil at a higher temperature under such conditions; food, therefore, cooks much more quickly.

The following table will show how the boiling-point rises with the pressure:

	Degrees.
At atmospheric pressure, 10,000 feet above sea level	194
At atmospheric pressure, 5000 feet above sea level	203
At atmospheric pressure, at the sea level	212
At 5 pounds steam pressure	227
At 10 pounds steam pressure	239
At 15 pounds steam pressure	250
At 20 pounds steam pressure	259
At 25 pounds steam pressure	267

Boiling Point of Different Substances.—Not all substances boil at the same temperature. The following table gives a few of the common substances which have different boiling points.

	Fahrenheit.
Water	212°
Alcohol	172
Ether	98
Gasoline	112–140
Mercury	674
Sulphur	831
Kerosene	365–392

Other Things which Affect Boiling Point.—Boiling point is affected by the presence of impurities. If salt is added to water it will boil at a higher temperature. Why does sea water boil at a higher temperature than fresh water?

The rise in temperature is usually in proportion to the amount of impurity added. This is also true of sugar. Confectioners determine the amount of sugar in their solutions by finding the boiling point.

Plain sugar syrups:

	Fahrenheit.
For syrup, 11 pounds to the gal.	219°
For fondant candies	236
For fudge and other candies of like nature	240
For taffy and like hard candies to be pulled	300
For clear brittle candies, peanut brittle, etc.	310
For almonds and walnut brittle	315

The boiling point of water is higher in some dishes than in others; for example, when the water is boiling at about 212° in a copper dish, the boiling point in a glass flask is about 213°.

Wegener's "Profile of the Atmosphere." * — The lowest dotted line (about 7 miles above the ground) is "where the air stops growing colder." It is the upper limit of ordinary clouds, of storms, and of balloon ascensions by human beings. Nearly all the moisture of the atmosphere lies below this

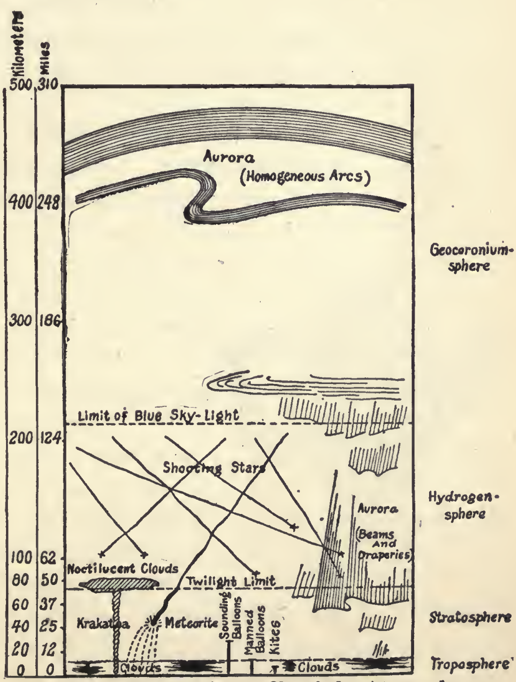


FIG. 66.—Wegener's Profile of the Atmosphere.

* Taken from the Scientific American Reference Book.

level. Above this line comes the second layer of the atmosphere, the stratophere (also called the "isothermal layer," because a thermometer carried up through it would show little change of temperature, with change of elevation). This layer has been penetrated by sounding balloons, carrying meteorological apparatus but no human aeronaut, as far as 20 miles above the earth. At about 50 miles—the upper limit of twilight—begins a region in which the atmosphere consists chiefly of hydrogen. Near the lower border of this region clouds of fine dust have sometimes been observed, shining by reflected sunlight on summer nights. These "noctilucent clouds" are commonly explained as the product of volcanic eruptions on the earth (they were frequently seen after the eruption of Krakatoa), but may be of cosmical origin.

Concerning the uppermost regions of the atmosphere we have little positive knowledge. Above about 130 miles from the earth Dr. Alfred Wegener, the author of this diagram, believes that a gas ("geocoronium"), much lighter than hydrogen, prevails, to which he attributes the characteristic green line in the spectrum of the higher auroras. This is hardly more than a guess at present.

Questions

1. Why does water boil more easily on some days than on others?

2. Why do people say " it is going to rain," when the " kettle boils easy."

3. How could one tell the height of a place by finding the temperature of boiling water ?

4. Why will a heavy cover over a dish cause vegetables to cook more quickly?

Fig. 65*a*.

5. Why is it impossible to boil eggs (hard) at high altitudes unless the cover of the kettle is weighted down?

6. If the atmosphere were all removed from the earth, would the ocean boil? Why?

7. Would ice water boil in a vacuum?

8. Why does candy boil so vigorously when flavoring is added? (Suggestion: There is alcohol in the flavoring.)

9. What causes the water to rise in a coffee percolator?

10. What part of each section of this Chapter did you like best?

11. What part of the Chapter do you consider of greatest importance? Why?

CHAPTER IV

TRANSMISSION OF HEAT

RADIATION

The Sun as a Source of Heat.—The most important source of heat is the **sun**, which is continually sending to us light and heat waves. The sun has a temperature of about 10,800° F. It has been estimated that a solid column of ice $2\frac{1}{2}$ miles in diameter reaching from the earth to the sun, a distance of about ninety-two million miles, would melt in a single second if the entire heat of the sun were concentrated on the ice. If the sun were composed of solid coal, and we derived our heat from the burning of the coal, it would burn out in less than five thousand years. Since the earth is millions of years old, the sun cannot be burning. It is really heated to glowing point like a piece of white-hot iron. A scientist named Helmholtz first satisfactorily explained why the sun continues to give off heat. He advanced the idea that the sun was contracting about 250 feet each year. In other words, the enormous weight of the sun causes tremendous internal contraction which produces great quantities of heat. Newcomb, another scientist, has estimated that in about seven million years the sun will be one-half its present size. (Compare the size of the sun with that of the earth in Chapter XIII.)

How the Heat of the Sun Reaches the Earth.—We know how much colder the air gets as we ascend. About 10 miles above the earth the temperature of the atmosphere is about 90° below zero Fahrenheit, while the space beyond our atmosphere is estimated to have little, if any-heat, the temperature being about 459° F. below zero. This would seem to tell that the sun does not send us heat directly. Across this enormous cold space light and heat waves travel without warming any part of space, because, as is believed,

this vacuum beyond our atmosphere is full of a transparent, intangible, and invisible medium called **ether.** These heat and light waves are known as **radiant energy.** This radiant energy is changed into heat when it is absorbed by some opaque object.

If you put your hand on a window-pane through which the " sun is shining," the window will feel cold while the window-sill will feel very warm. Air, glass, and many liquids are transparent; that is, they allow the light to pass through them freely. The radiant energy, which is coming from the sun and traveling at a rate of about 186,377 miles per second, passes through transparent objects without losing any heat. When the radiant energy strikes the window-sill, which is opaque, it is absorbed and transformed into heat. The process of getting heat from the sun is called **radiation.**

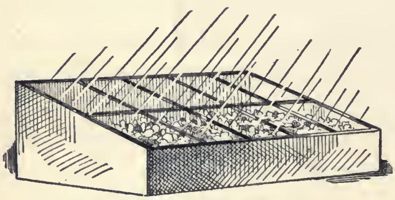


Fig. 66.

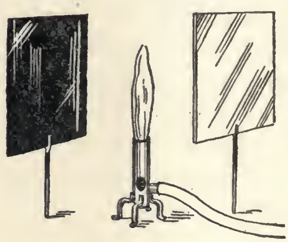


Fig. 67.

Hotbeds and hothouses are covered with glass to allow the radiant energy to pass through and be absorbed by the earth. It is then changed into heat, which cannot pass out through the glass.

Dull and Shiny Objects.—If we stand near a fire, we feel the fire sending off great quantities of heat by radiation. When radiant energy falls upon any object it may be reflected by the surfaces of the object, absorbed, or transmitted through the substance.

Stand two pieces of metal (one shiny and the other black) upright about a foot apart. Place between them a bright light.

In a short time the black metal will be found to be warmer than the shiny metal. The dark metal was heated by the radiant energy while the shiny metal reflected the heat and light. Because it reflects light, white clothing is cooler for use in summer.

Why Water does not Heat as Quickly as the Soil.—Water does not heat as quickly as the soil for two reasons. The surface of the water reflects more heat when calm than when it is rough. This reflection often causes sunburn, since our skins are opaque and absorb great quantities of radiant energy. The water is also transparent; hence the radiant energy will penetrate several hundred feet in the water, while on the soil all the radiant energy is absorbed near the surface, usually not extending much below the roots of plants.

Why Soil Cools off Faster than Water.—Things which absorb radiant energy quickly also radiate heat quickly.

Fill two cans (one shiny and the other black) with water at the same temperature. Cover each can with a piece of wood. Take the temperature of the water every few minutes. Prove that dull, black objects give off heat more quickly than shiny objects.

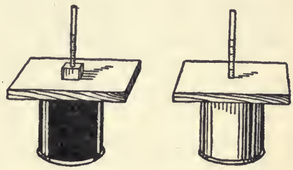


FIG. 68.

A black, sooty cup radiates heat twenty times faster than a bright, shiny cup.

The rocks and soil of the earth radiate heat much more quickly than water. In fact, things which absorb heat quickly also radiate heat quickly, and things which absorb heat slowly radiate heat slowly.

Radiation and the Household.—Hot objects, like stoves and steam pipes, lose much of their heat by radiation, and the blacker the objects the more they will lose; hence, stoves and steam pipes should be black, if they are intended to give out heat; but hot-air pipes, cooking utensils, etc., should be bright (tinned or nickeled) in order to lose as little heat as possible. A stove nickel-plated all over will give out only about half as much heat as the same stove at the same temperature, if black. Brightly tinned hot-air furnace pipes often lose less heat when bare than they do when covered with one or two layers of asbestos paper, since the asbestos paper radiates heat so much more readily than the bright tin that it more than balances the insulating effect of the thin asbestos covering. Of course, if the pipes were black to begin with, the covering would be

useful, and if the insulating material were thick enough (say $\frac{3}{8}$ inch or more), it would save heat even on bright tin pipes.

A bright nickel or aluminum kettle will cool very much more slowly than a black kettle. On a coal or wood stove, or directly over a coal or wood fire, a kettle is heated largely by heat radiated from the stove or fire; therefore if the bottom is black, the kettle will heat more rapidly than if it is bright. Over a gas, gasoline, or similar blue flame, the condition of the bottom will not make so much difference, since here most of the heat is received by contact with the hot gases. The best kettle for general use is, therefore, one with the bottom black and the remainder polished, but for use on a gas stove it makes little difference whether the bottom is black or not.

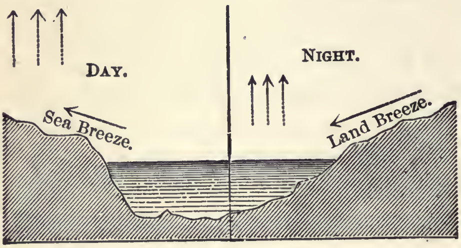


FIG. 69.—Why do we have a sea breeze during the day and a land breeze at night?

Effects of Painting Radiating Surfaces.—The amount of heat given off by radiation from a radiator is small, probably not exceeding on an average 40 per cent of the total amount emitted. If we consider that a new surface of cast iron will give off 40 per cent of the total heat by radiation, the following table will give some idea of the results obtained by radiation from various surfaces.

	Per cent.
Cast iron, new	40
Wrought iron	37
Dull lampblack	42
Rusty surfaces	41
Bright iron surfaces	29
White lead, dull	42

It is found that two coats of black asphaltum paint increase the amount of radiation 6 per cent, two coats of white lead 9 per cent, rough bronzing about 6 per cent. A coat of glossy white paint reduces the heat emitted by radiation about 10 per cent.

How Moisture and Dust Interfere with Radiation.—During the passage of radiant energy through the air, some of it is absorbed by the dust particles and moisture which keep the air from being absolutely transparent. The amount of heat obtained by the atmosphere directly is small, and especially so on high mountains where there is little dust and moisture in the air. The important thing is the interference with radiation during the night by moisture and dust. More heat is retained near the earth on hazy and muggy days than during clear days and nights. On high mountains the earth will become heated very quickly during the day, but at night the heat radiates just as quickly, since the atmosphere is far more transparent than that down in the valleys.

Radiometer.—Darken the room. Place a radiometer on the table near a bright flame. The radiometer vanes will be seen to move very rapidly. If the light is a Bunsen burner, allow air enough to enter to make the flame blue. The vanes on the radiometer will go around more slowly. The radiant energy from the bright flame passes directly through the glass, and is absorbed very quickly by the black vanes, but is reflected by the bright vanes. Much of the air has been exhausted from the bulb of the radiometer. The tiny particles or molecules of air remaining strike the blackened surface and rebound with greater velocity than from the other side, thus exerting great pressure.

Fig. 70

Water will boil much more quickly over a blue flame than over a yellow flame. This shows that a blue flame is very much hotter. Less radiant heat is given off by flames which give off little light.

Season Due to the Slant of the Sun's Rays.—If we allow *AB* to represent a section of the earth during the summer time, and *CD* a section of the earth during the winter time, it is easily seen that more radiant heat from the sun will be absorbed by the section of the earth in the summer than in the winter. In the summer

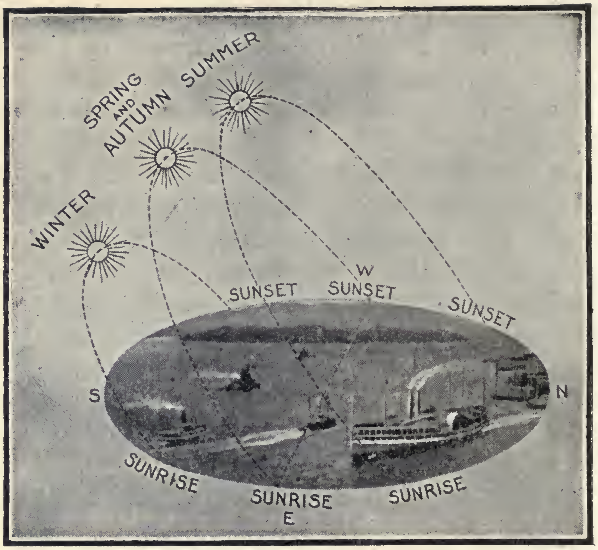


FIG. 71.—The daily course of the sun at the time of the solstices and the equinoxes.

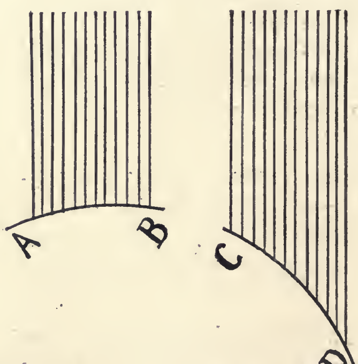


FIG. 72.—The rays A B strike the earth vertically the rays C D strike in a slanting direction. As D C is longer than A B, the same number of rays are spread over a greater surface and give less heat.

time the twelve rays are distributed over that part of the earth represented by AB, but in the winter the same number of rays are distributed over CD. Fig. 72.

At midday the rays of the sun are more vertical than in the morning and afternoon; hence, we get the greatest amount of heat at that time.

Questions

1. Why are thermos bottles shiny?
2. Why should radiators be dark and rough?
3. Why do soldiers wear white uniforms in the tropics?
4. Why are the streets of a city, or the stone walls of a quarry, warmer than the open country?
5. Why will snow melt faster under black cloth than under white?
6. Why wear white during the summer months, and black during the winter months?
7. Which would be the coolest in summer, white, tan, or black shoes? Why?
8. What would be the difference between trying to keep water warm in a glass bottle and in a shiny aluminum bottle?
9. Why does snow covered with dirt melt much faster than new snow?
10. Why are ashes helpful on ice?
11. What would be the difference in the amount of heat received by us if the sun were the color of the blue flame of a Bunsen burner?
12. Why doesn't the earth get heated just as much by radiation on a cloudy day?
13. Why is water warmer in the evening than the adjacent land?
14. When will you get the greater sunburn—when the sea is rough or smooth? Why?
15. Why will frost appear more quickly on a clear night?
16. Why will dark soils absorb heat more rapidly than light-colored soils?
17. Why will the bare earth become heated more quickly than earth covered with vegetation?
18. Why doesn't the frost in central Alaska, which often extends 175 feet down in the earth, go out during the summer?

19. Why do we have an oppressive night after a muggy day?

20. Why is the bottom of a teakettle rough and black?

21. What should the sides of a teakettle be like? Why?

22. Why are furnace pipes polished?

23. What is the advantage and the disadvantage of a highly polished stove.

24. How does the glass in a hothouse act as a trap to catch heat?

25. Does the heat of the sun come through the window?

26. Why are the tops of mountains so cold although nearer the sun than the valleys?

27. Why will a slight covering over plants prevent frost?

28. Why is there no frost on a cloudy night?

29. How do we get the greater part of our heat from a fireplace? Why is not the fireplace as economical as a stove?

30. Why are the connecting pipes of a boiler polished?

31. Why is china glazed?

32. Why may flowers be raised under glass out-of-doors during the winter?

33. Why does the snow melt at the foot of a tree more quickly than in the open field?

CONDUCTION

Difference between Conduction and Convection.—There are two other ways by which heat is transmitted: conduction, which is to be studied in this section, and convection, which is to be studied in the next section.

To get a clear idea of the difference between the two methods, pass a book from one student to another along the class. The book is conducted or passed from pupil to pupil. Heat travels in the same manner. The heat is given from one particle or molecule to another of an iron bar, one end of which is in a flame, and the other end in your hand. In this way the heat is conducted to your hand. The heat has traveled by **conduction.**

If one of the pupils carries the book from one end of the class to the other, we may call this method of getting the book from one place to another **convection.** Most solids transmit heat by conduction, while liquids and gases transmit heat by convection. Air

and water are used chiefly for transmitting heat by convection. A furnace heats the water or air which in turn carries heat as it travels throughout the building.

Substances at the Same Temperature Feel Different.—The better heat conductors take heat from the hand more rapidly than do poor conductors. In the same room, with all objects at the same temperature, the bare floor will feel colder than a rug. This is because the floor takes the heat away from the hand more rapidly than the rug.

FIG. 73.

Place a thermometer on several objects in the room which seem of different temperatures. The thermometer will register the same temperature for all.

With the hand, test as many substances in the room as possible. Tell whether they are poor, medium, or good conductors.

Different Substances Conduct Heat at Different Rates.—Cover several pieces of wire of different metals with heat-indicating paint. Arrange each metal so that one end is over the mouth of a flask from which steam is coming. The other ends of the metals may rest on blocks of wood. Prove that the metals conduct heat at different rates. Compare the rates you obtain with the table on page 96.

Heat-indicating Paint. Equal parts of iodide of mercury and iodide of copper rubbed down with sufficient distilled water to produce a spreadable paste make a temperature-indicating paint which turns black between 140° F. and 206° F. and returns to its red color on cooling. (Red iodide of mercury works best.)

A yellow iodide of mercury and of silver is far more sensitive to heat than the above paint. The yellow paint changes from yellow to red as the heat is conducted along the metal.

From the table it will be seen that silver is the best conductor of heat and air one of the poorest.

Try several teakettles, placing the same amount of water in each and noting the time required to bring the water to boiling point. If the kettles do not have bottoms of the same size determine whether this has any effect on the time required to heat the water, and the consequent waste or saving of gas. Try to find other important factors beside the conductivity of the metals. Measure the amount of gas consumed, and determine the amount saved if kettles of the proper kind are used.

TABLE

Material.	Thermal Conductivity.	Transmission in Btu. per Hr., per Sq. Ft. per in. Thickness for Each Degree F. Difference in Temp.
1. Silver	100	2900.0
2. Copper	90	2600.0
3. Aluminum	50	1950.0
4. Brass	27	
5. Zinc	26	
6. Tin	14.7	
7. Iron	14	460.0
8. German silver	8.4	
9. Mercury silver	1.7	
10. Rock	.25–.9	0.7 to 26.0
11. Granite	.53	
12. Limestone	.52	
13. Ice	.5	
14. Porcelain	.25	7.2
15. Brick	.2–.5	6.0 to 15.0
16. Glass (ordinary)	.16	4.6
17. Water	.14	4.0
18. Plaster (ordinary)	.1–.15	2.9 to 4.3
19. Wood (hard)	.06	1.7
20. Asbestos paper	.045	1.3
Asbestos felt	.025	.7
21. Sawdust	.018	.52
22. Wood (very soft)	.015	.43
23. Paper	.013	.38
24. Cork board	.012	.34
25. Wool	.010	.29
26. Hair felt	.010	.24
27. Cotton wool	.009	.26
28. Feathers	.0057	.16
29. Air	.005	
30. Silk	.000095	
31. Snow	.00051	
32. Leather	.00037	

Poor Conductors.—Water is a poor conductor of heat, as may be shown by nearly filling a test tube with water, and, with a piece of wire, fastening some ice at the bottom of the tube. Heat the test tube near the top. Soon the water in the top will boil, while ice remains in the bottom of the tube. You will then have boiling water at one end and ice water at the other. Carefully notice on what part of the side you heated the tube. Prove that water conducts heat very poorly.

Air is another poor conductor, especially dry, dead air. By dead air we mean air not in motion. Damp air does not conduct

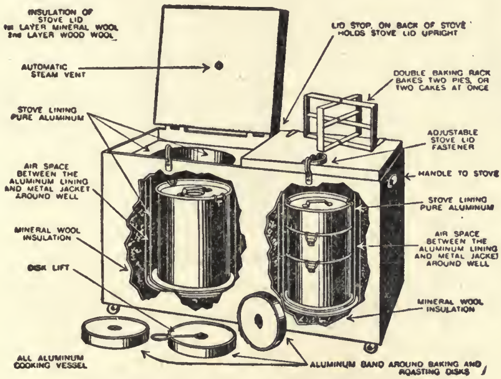


Fig. 74.

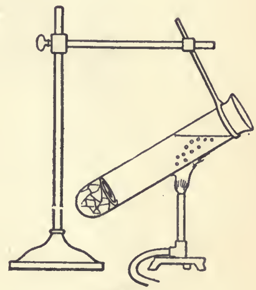


Fig. 75.

heat very rapidly unless in motion. Often a person may remain in damp, still air without any great discomfort, after the moisture in contact with the body has been heated.

Water under a bridge will not freeze for some time after the water in the open has frozen. Shawls with many openings filled with dead air are very warm. Birds often ruffle up their feathers on a cold day to get plenty of dead air among the spaces between the feathers.

To prevent the air from circulating, charcoal, sawdust, and other porous substances are often loosely packed into spaces between walls. Leather, paper, fur, felt, woolen cloth, animal wool and many other solids are poor conductors.

Why is the porcelain enamel lining used at A? Fig. 76.

Why is the inside lining at B made of wood?

Why is 3-ply red rope waterproof paper used at *C*?

Why is wool felt deafening paper used at *D*?

Explain the use of flaxlinum insulation at *E* and *F*, dead air spaces at *E*, 3-ply red rope waterproof paper at *H*, and the outside wood case at *I*.

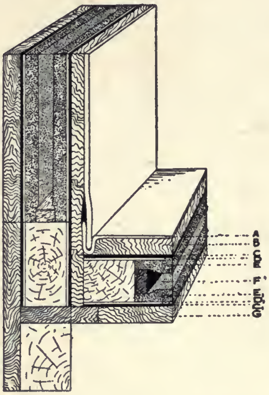


Fig. 76.—Section of a Refrigerator.

Fig. 77.

THERMOS BOTTLE

Why is a cork stopper used?

Why is the bottle placed on a spring (two reasons)?

Why is a space left between the outer case and the bottle?

Why is the bottle made in two sections with a vacuum between the inner and outer bottle?

Why is the bottle made very shiny?

Questions

1. Why do soup companies use copper and nickel kettles?
2. Why are flatiron handles made of wood?
3. Why is ice packed in sawdust or straw?
4. Why do late spring snows melt from stone walks more quickly than from board walks?
5. How does clothing keep us warm?
6. Why are plants covered with paper at night to keep them from freezing?

7. Why do woodsmen often wear paper vests? Why do we put newspaper in our shoes to keep our feet warm?

8. Which of these substances would be best for a stove—iron, brick, or soapstone? Why?

9. How are safes made fireproof?

10. Why are stove lifters, oven door-handles, etc., made of coiled wire?

11. Why are dead air spaces left between the walls of a building?

12. Why do Eskimos wear one skin with the fur next to the body, and the other with the fur outside?

13. Why do animals have thick fur in winter?

14. Why do birds ruffle up their feathers on a cold day?

15. Why does loosely woven material keep us warmer than tightly woven material?

16. Why are shawls, sweaters, etc., said to be very warm?

17. Why does food continue to cook after being placed in a fireless cooker?

18. Why is it better to make the outside pail of an ice cream freezer of wood than of metal?

19. Why does plenty of snow keep the grass roots from freezing?

20. Why does linoleum feel colder to the bare feet than a woolen carpet?

21. Why do firemen wear flannel shirts?

22. Why is it possible to set paper afire with a burning glass?

23. Why do farmers prefer a winter with abundant snowfall?

24. Why do rubbers cause the feet to feel very warm if worn in the house?

25. Why do we use a woolen blanket to cover the ice in summer and to cover ourselves in winter?

26. Why will the hand on a frosty morning freeze to a metallic surface more quickly than to a brick one?

27. In taking bread from the oven, why will the hot pan burn your hand wherever it touches you, while the bread and the air of the oven do not, although of the same temperature?

28. Why may a glass rod be melted in a flame and held in the hand with comfort a few inches from the melting place?

29. Why are hob-nail shoes very cold in winter?

30. Why will mist clear from lenses surrounded with gold rims more quickly than from rimless glasses?

CONVECTION

Conduction and Convection as Applied to our Clothing.—Air which cannot circulate and carry heat by convection is one of the best heat insulators to be found. Cotton, wool, feathers, cork, etc., are good insulators because they contain a large amount of air in the cells or in the spaces between the fibers. Clothing keeps in the heat of the body chiefly because it contains air between the layers and in the meshes of the cloth. When the enclosed warm air is displaced and is replaced by colder air, as is the case in windy weather, the clothing no longer keeps one so warm. If clothing is closely fitting, there is less room for an air layer between the layers of clothing, and, therefore, it is less warm. To keep one warm in cold, windy weather the clothing should consist of loosely-fitting garments, preferably of wool, with some outside wrap which is nearly wind proof, such as very closely woven cloth, or even leather or rubber. A fur coat is very much warmer if the fur is on the

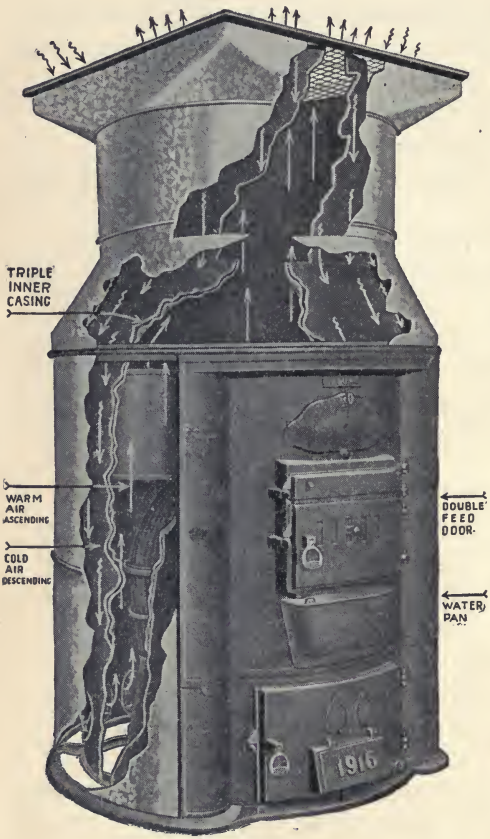


Fig. 78.

inside, where the wind cannot disturb the air which is held among the hairs, than if the fur is on the outside.

Why Water Carries Heat.—Water at about 40° F. weighs about $62\frac{1}{2}$ pounds per cubic foot or 436,961 grains per cubic foot. If the water is heated to boiling, a cubic foot will weigh 418,320 grains, or 18,641 grains less. That is, water weighs, on the average, about 108 grains less per cubic foot for every degree Fahrenheit it is heated.

This is due to the fact that 1728 cu. in. (one cubic foot) of water when heated from 40° F. to 212° F. increases in volume until there are about 77 more cubic inches of water (about 1805 cu. in.). The weight of the cubic foot of hot water is equal to the weight of about 1651 cu. in. of the cold water which have expanded to 1728 cu. in.

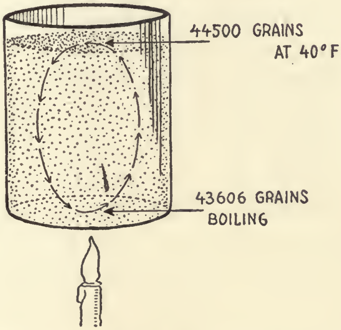


Fig. 79.—Why will water as it heats rise to the top of the vessel? Why will the water at the top sink?

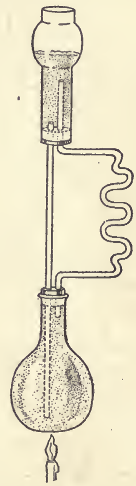


Fig. 80.

The heated water will be lighter than the cold water; hence, it will rise to the top of a kettle, while the cold water, being heavier, will sink. Naturally, the heat will be carried by the lighter water to the upper part of the vessel. We have already defined this method of carrying heat as **convection.**

Experiment to Show how the Water Gets Hot in a Kitchen Boiler.—Construct apparatus as shown in the diagram, Fig. 80. Fill

with water. Add a small amount of red ink to the water in the student's lamp chimney. Heat the water in the flask.

Why does the colored water run down the straight tube into the flask? Why does the uncolored water in flask rise in the crooked tube to the student's lamp chimney?

Why Air Carries Heat.—One cubic foot of air weighs 0.07203 pound or 504 grains. For every five degrees the air is heated it weighs between 4 and 5 grains less; hence, the heated air, being lighter than the cold air, will rise and float above the cold air, while the cold air, being heavier, will sink.

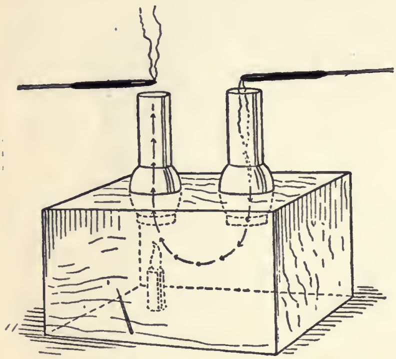


FIG. 81.—Is the smoke pushed or pulled down the chimney? Why?

Experiment to Show the Convection of Air.—Arrange two chimneys over holes cut in the sides of a chalk box. Stand the box on the opposite side and substitute a piece of glass for the cover. Place under one chimney a candle. Hold over the other chimney a piece of Chinese joss stick, or a piece of touchpaper made by soaking the paper in a saturated solution of saltpeter. Why will the smoke go down the chimney? Why is the smoke soon seen coming out of the other chimney? Why will the smoke not go down the chimney which has the candle burning under it?

The table on page 103 will be found useful in determining the weight of the atmosphere of any room. For example, suppose the room is 10 feet wide by 20 feet long by 15 feet high; the room will hold 3000 cubic feet of air. Suppose the barometric pressure is 30, the relative humidity 60 per cent, and the temperature 65° F. From the table, the weight of each cubic foot of air (dry) at 65° F. is 0.07203. Since the barometric pressure is 30 it is necessary to add one-half of 0.002530 or 0.001265. Also six times 0.000059 must be subtracted since the relative humidity is 60 per cent.

$0.07203 + 0.001265 - 6(0.000059) = 0.072941$, weight of 1 cubic foot of air 65° F., 60 per cent relative humidity, barometric pressure 30.

0.072941 times 3000 cubic feet = 218.8 pounds, weight of the air in the room.

Temperature Degrees Fahr.	Weight of 1 Cu.ft of Dry Air at 28.5 In. Barometric Pressure, Lb.	Weight in Grains.	Increase or Decrease of Weight for each 0.1 Lb. Change in Pressure, Lb.	Increase or Decrease of Weight for Each 1 In. Change of Barometric Pressure, Lb.	Decrease of Weight for Each 10 Per Cent Increase in Relative Humidity, Lb.
32	0.07688	538	0.000549	0.002698	0.000019
35	0.07642	535	0.000546	0.002681	0.000021
40	0.07565	529	0.000540	0.002654	0.000025
45	0.07490	524	0.000535	0.002628	0.000030
50	0.07417	519	0.000530	0.002602	0.000035
55	0.07340	514	0.000525	0.002580	0.000040
60	0.07272	509	0.000520	0.002554	0.000051
65	0.07203	504	0.000515	0.002530	0.000059
70	0.07134	499	0.000510	0.002506	0.000070
75	0.07068	495	0.000505	0.002482	0.000081
80	0.07003	490	0.000500	0.002457	0.000095
85	0.06938	485	0.000495	0.002432	0.000111
90	0.06875	481	0.000490	0.002408	0.000127
95	0.06811	476	0.000485	0.002384	0.000147
100	0.06752	472	0.000480	0.002359	0.000172
105	0.06694	468	0.000475	0.002334	0.000199

To change pounds to grains multiply by 7000.

Heating of a Room with a Radiator.—The heat is brought to the inside of the radiator by convection from the furnace in the basement. Some of the heat escapes into the room by radiation, as has already been mentioned, but the greater part of the room is heated by convection. The heat passes from the inside of the radiator to the outside by conduction. The air, coming in contact with the radiators, in turn becomes heated, also by conduction. This heated air rises, being pushed up by the cold air rushing in toward the radiator. The air at the ceiling cools slightly and sinks, coming in contact with the objects of the room and giving up heat.

Heating of Air by Convection.—Heating by hot-air furnaces is already more or less popular. There are some things which it is very

FIG. 82.—The arrows show the circulation of air as produced in the room by the radiator. Why does the air over the radiator rise? If the hot air is rising why do you feel heat if you stand beside the radiator? Why does the air on the opposite side of the room fall and return toward the radiator?

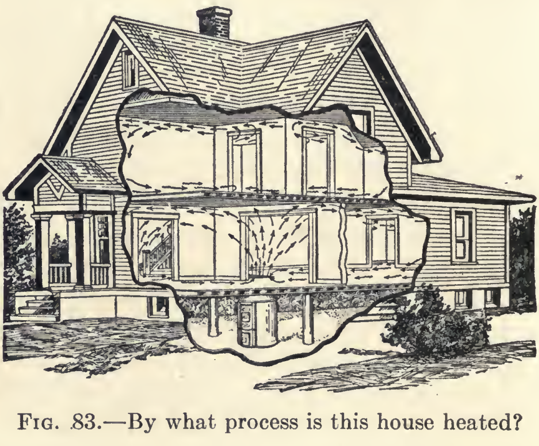


FIG. 83.—By what process is this house heated?

important that we should know about this form of heating. The manner in which the air enters the room should be considered first.

Authorities differ somewhat, but experiments have shown some valuable things regarding inlets and outlets for hot air-heating.

The best location for air inlets has been found to be near the ceiling of a room, since the warm air tends to rise and spread uniformly under the ceiling, gradually displacing other air, and filling the room with pure air without causing drafts. The colder air will of course pass out of the outlets near the bottom of the room. This system requires a fan to force the air into the rooms and is mainly used for supplying fresh air, as well as heat, to all parts of the building. We shall learn more of this under the subject of ventilation.

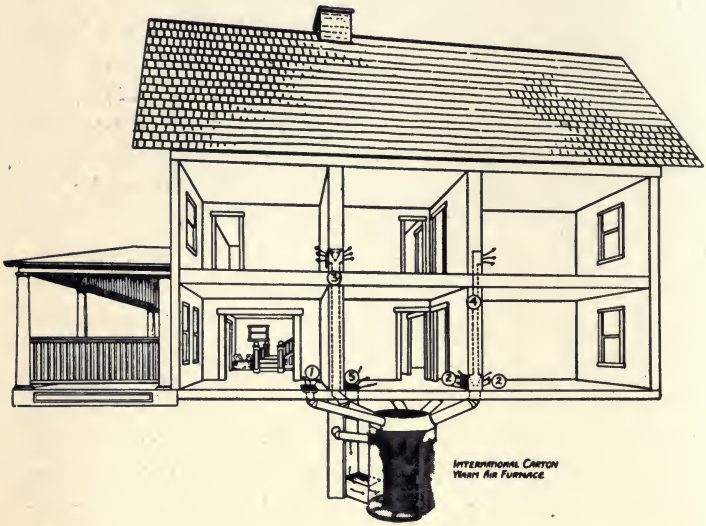
The fan used for forcing the air through a building should be carefully selected. Small fans must run very rapidly in order to supply enough warm air to the rooms. They also set the air in rapid vibration, causing a buzzing sound. Large fans may be run at less speed, and will deliver the same amount of air without causing drafts or annoying sounds. The difference in cost will be neutralized by less wear and tear on the large fan.

The diagrams on page 179 give an idea of the movements of air for different positions of the inlets and outlets for ventilation.

Chimneys.—A chimney is used for two purposes; first, to create draft necessary to supply burning fuel with sufficient air; second, to furnish a means for discharging noxious products of burning into the atmosphere at such a height from the ground that they may not be a nuisance to people living in the vicinity of the chimney.

The " draft " of a chimney depends upon the difference in weight between the air inside and the same volume of air outside. The chimney should be tall enough to enclose enough heated air to cause the right amount of air pressure for a good " draft." The chimney should be provided with a " clean-out door " at the base, 3 or 4 feet below the smoke-pipe entrance. Chimneys should ex end above the highest surrounding roof, to prevent down drafts caused by eddies. Where it is impossible or impracticable to build the chimney high enough revolving chimney tops will often prevent down drafts. Down drafts may also be prevented by covering the top of the chimney with stone flag, leaving openings in two parallel sides of the chimney, the sides parallel to the ridge of the adjoining roof or building being closed.

The chimney should be built near the center of the house, that it may not lose heat from contact with the outside cold air. The general rule for building chimneys standing alone is to make the diameter of the base, or the width of the side of a square chimney, one-tenth of the height.

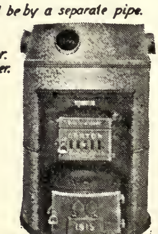


Typical Warm Air Furnace Installation with inside air circulation

The Furnace is located near the center of the house with all heat pipes as nearly equal in length as possible.

① The heat is distributed through a floor register, these are very commonly used for all first floor rooms.
② Where side wall registers are used a pattern should be selected that does not restrict or contract the flow of air.
③ One riser pipe will usually heat two small second story rooms as shown.
④ If a room on the second floor is used only occasionally it might be connected as shown: a better way would be by a separate pipe.
⑤ As the air in the rooms cools it falls to the floor
The area of the recirculating duct must equal in cross section that of all the heat pipes.

The Furnace shown is an all cast iron pattern of heavy durable construction and having a self cleaning radiator. It is designed to burn either hard or soft coal, its self-cleaning feature making it especially desirable with the latter.
With ordinary care it should give satisfactory service for more than twenty-five years.



A Furnace Cased, before heat pipes are attached.

FIG. 84.—Warm Air Furnace Heat.

Refrigerators.—There are two usual types of refrigerators—top icing refrigerators and side icing refrigerators. They work on the same principle. The air next to the ice becomes cool, and sinks through the bottom openings of the ice chamber into the main part of the refrigerator, while the warmer air from the upper part of the refrigerator enters the top of the ice chamber and is cooled. There is a continuous circulation of air past the ice and through the food chambers. This circulation is important because it distributes the cooled air to all parts of the refrigerator, and also because on passing the ice, the air loses some of the moisture and the odors which it has taken up from the food, especially that which is not yet cold. Therefore, anything which retards this circulation or stops up the openings of the ice chamber should be avoided.

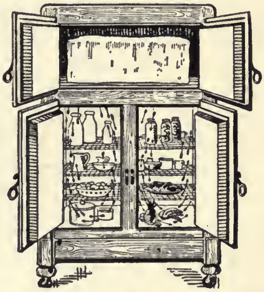


FIG. 85.—Why is the milk on the top shelf? Why will not the milk keep as well on top of the ice?

The lowest temperature inside a refrigerator ranges from 44° F. to 57° F., and the highest from 64° F. to 72° F. This difference in temperature causes the circulation of the air in the refrigerator. By referring to the diagram it will be seen that the air around the ice weighs more than the air above the ice.

It has been found that milk kept at 60° F. will develop in one day fifteen times as many bacteria as milk kept at 50° F. The same thing is true of many other foods. It is important, therefore, to find the coldest place in a refrigerator and use this place for foods, such as milk and meats, which need to be kept as cool as possible to prevent spoiling. The coldest place would naturally be directly under the ice.

Slow melting of the ice does not necessarily indicate a good refrigerator. Unless the ice melts it can absorb no heat, and is therefore of no use in a refrigerator. Protecting the ice in a refrigerator by covering it up is a good way to save ice, but a **poor way to save food.** The only proper way to use less ice is by using a refrigerator with better insulated walls, and by opening the doors as seldom and for as short intervals as possible.

The Jacketed Stove.—One-room school buildings are often heated by jacketed stoves. The jacketed stove consists of an ordinary stove surrounded by sheet iron casing set 6 or 8 inches from the

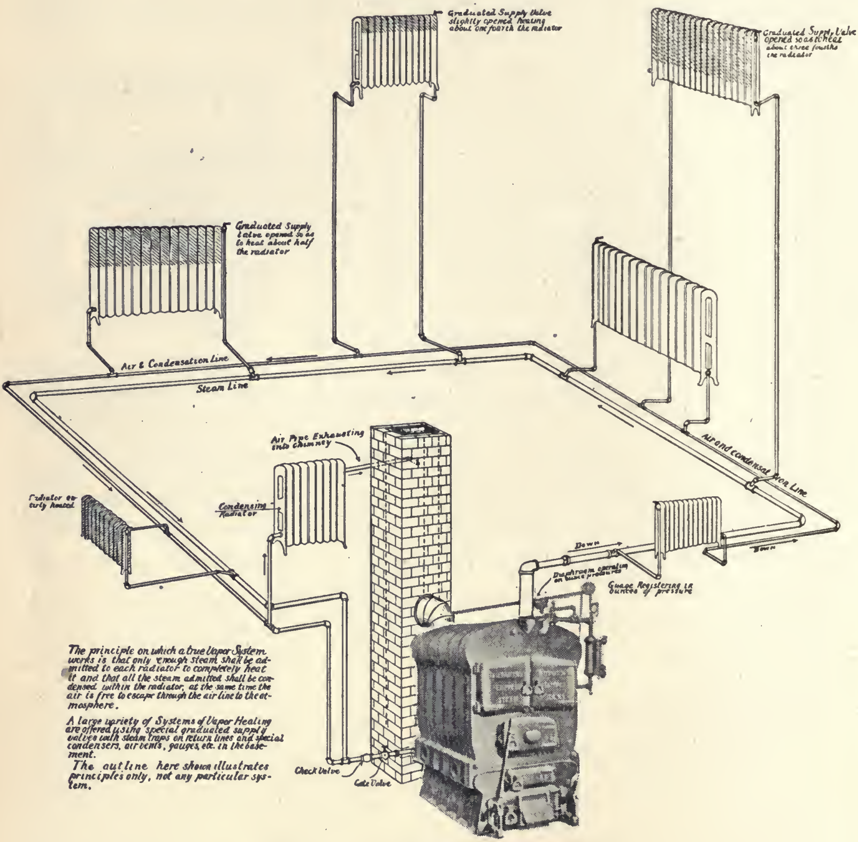


FIG. 86.—Vapor Steam Heat.

stove. The ordinary box stove without this "jacket" or "casing," when used to heat schoolrooms, does not distribute the heat of the room equally. Those near the stove will suffer from a great amount of radiant heat given off, while those at a distance will suffer from

the cold. The jacket allows the cold air to enter at the bottom, usually from outdoors, through a duct. The air circulates through-

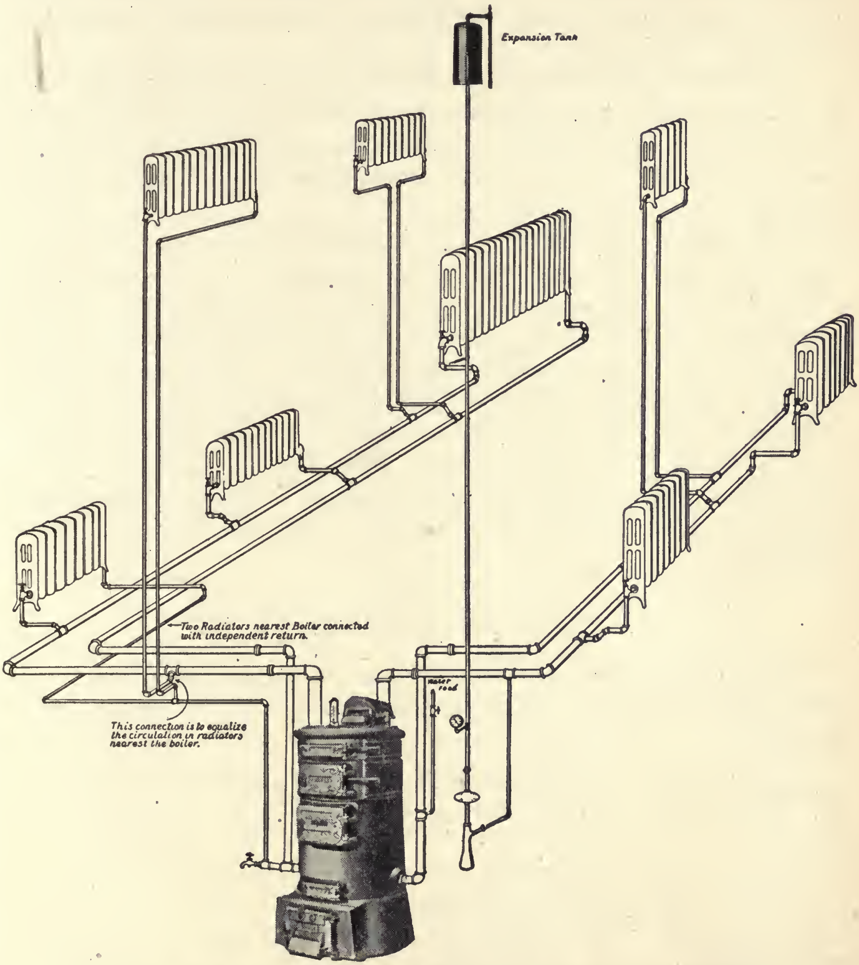


FIG. 87.—Hot-water Heat. Why is the expansion tank necessary?

out the room, and tends to equalize the temperature. In the diagram the ventilators have been placed on the sides of the room to

allow the foul air to escape. At the same time the heat of the smoke warms the air in the vent flue and causes an upward draft from the floor which removes the foul air. This method is very effective for heating rooms, but is not very highly recommended as a means of ventilation.

Convection and Ventilation.—It will be seen from the work under convection that all our methods of obtaining pure air make use of this process. The subject of ventilation, and the amount of air required for each person, will be studied carefully under the head of ventilation.

How the Air is Heated.—The atmosphere is warmed by radiation, by conduction, and by convection, just as a stove warms the air in a room. Radiation is more effective in warming the air than conduction, since the air must come in contact with the warm earth to get its heat by the latter process. Air is not perfectly transparent. Some of the radiant energy is, therefore, used in heating the air near the earth—air which is full of water vapor and dust. The higher portions of the atmosphere are chiefly heated by convection, since the air, becoming warmer and lighter nearer the earth, is therefore displaced by the colder and heavier upper layers of air.

SYSTEMS OF HEATING

The various systems employed for the warming of buildings, aside from the use of stoves and fireplaces, may be classified as follows:

Furnace heating	Natural-draft, or gravity system. Forced-draft, or fan system.
Steam heating	Gravity, or low-pressure systems: (1) Direct radiation. (2) Direct-indirect radiation. (3) Indirect radiation. Vacuum systems: (1) Paul system. (2) Webster system.

Steam heating	High-pressure systems: (1) Gravity-circulation with return-trap or pump. (2) Fan, or forced-blast system.
Hot-water heating	Open system: Direct or indirect. Closed system. Direct or indirect.

The above topics are to be assigned for investigation by the class.

Questions

1. What makes a fireplace smoke?

2. Why will a piece of burning paper held up the chimney often stop the smoking?

3. Why will open windows make the chimney "draw" better?

4. Why are chimneys often covered with a stone flag, and openings left in two parallel sides in the chimney?

5. What sides of the chimney should be left open?

6. Why do we have land breezes at night, and sea breezes during the day?

7. Why is there usually a "calm" about sunset?

8. Why is it frequently difficult to warm a room on the north side of a house by a hot-air system?

9. What is observed rising over a radiator? Why does it rise?

10. Why not have a chimney on the outside of a house?

11. Which would be better for ventilation, a fire-place on the opposite side of the room from the windows or on the same side? Why?

12. Draw a diagram illustrating currents of air?

13. At what time of the year may a room be most quickly aired out? Why?

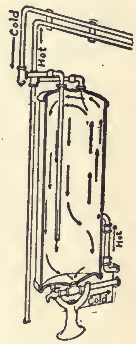


Fig. 88.—Why is it possible to heat the water in the tank? Where will the hottest water be found in the tank? Why?

CHAPTER V

EXPANSION AND HEAT MEASUREMENT

EFFECTS OF HEAT

Experiment to Show Expansion of Gas.—Fill a bottle half full of water colored with a little red ink; close with a one-hole rubber stopper through which runs a hollow glass tubing extending into the liquid. Place the hands on that part of the bottle which contains the air. The air will become warmer, expand, and force the liquid up the tube.

If air is heated 1° F., it expands $\frac{1}{461}$ of its volume. Suppose a room contains 3000 cubic feet of air, and the temperature changed from 32° F. to 65° F., making a difference of 33°. The air would expand until there were about 3214 cubic feet of air; that is, 214 cubic feet of air would be forced out of the doors and windows.

Air is called a gas. We may apply to all gases the same rule for expansion.

In some countries the unit of measure for the expansion and contraction of a gas is $\frac{1}{273}$ of its volume at 0° for every degree on the centigrade thermometer. (A thermometer to be studied later.)

The Use of Expansion of Air in Cooking.—The expansion of air is an important factor in cooking. We beat our various baking mixtures, such as graham flour mixed with water or milk, to fill them with air, which expands when exposed to the heat of the oven, and renders the cooked product "light." Some cakes, as genuine sponge cake, are made light solely by the introduction of air in the vigorous beating of the eggs. The "beaten biscuits" of the south illustrate how to make food light with no other aerating agent than air. The dough is beaten or kneaded, rolled or pounded, and folded over many times, until it contains large quantities of air.

Because a cold liquid contains more air than a warm one, we use ice water to mix up pastry dough. Eggs, when beaten to a froth, retain great quantities of air. Eggs are beaten in cool dishes and,

if possible, in cool places, since there will be a greater expansion of the air when the product is placed in the oven.

Experiment to Show the Expansion of a Liquid and a Solid.—Fill a flask with a red liquid. Close the flask with a one-hole rubber stopper through which extends a 2-foot piece of glass tubing with a very small bore. Place a paper at the top of the liquid in the glass tubing. Heat the liquid very slightly at first by allowing the flame to touch the flask for an instant. The liquid will suddenly drop and then rise. Repeat the heating; the same thing will occur each time. The glass is heated first, and the flask becomes slightly larger. The liquid will drop to fill up the extra space. Why does the liquid go back to the same level, and even higher after heat has been removed?

Continue to heat the flask for a few moments. The liquid will rise quickly because of its expansion. One hundred pints of water will become 103 pints of water if heated from 39° to boiling point (about 212°).

The Expansion and Contraction of Water.—Liquids usually expand with heat. Water expands when heated, if it has a temperature above 39° F. If, however, the temperature falls below 39° F. the water will gradually expand until it freezes at 32°.

The exact weight of 1 cubic foot of water at 62° F. is 62.355 pounds or $998\frac{4}{5}$ ounces. It is generally taken as 1000 ounces. At a temperature of 52.3° F. 1 cubic foot of water weighs exactly 62.4 pounds.

A gallon of water at 62° F.=0.1337 cubic feet=231 cu. in., and weighs $8\frac{1}{3}$ pounds. One cubic foot of water=7.48 gallons.

Expansion caused by Water Changing into Steam.—When water changes into steam exceptional expansion occurs. One quart of water will become about 1700 quarts of steam. The extra volume creates great pressure which is utilized for running engines in locomotives, steamboats, etc.

Why Corn Pops.—A kernel of popcorn is filled with starch grains. The interior of the kernel is divided into a large number of cells. The walls of these cells are sufficiently strong to withstand considerable pressure from within. Upon the application of heat, the moisture present in each little cell is converted into steam, and

WEIGHTS OF A CUBIC FOOT OF WATER AT VARIOUS TEMPERATURES

Degree Cent.	Degree Fahr.	Weight per Cubic Foot.	Relative Volume Water at 32 Degrees = 1.
	Ice.		
0	32	57.5	
	Water.		
0	32	62.416	1.00000
.56	33	62.418	
1.11	34	62.420	
1.67	35	62.421	0.99993
2.22	36	62.422	
2.78	37	62.423	
3.33	38	62.423	
3.89	39	62.424	
4.44	40	62.423	0.99989
5.00	41	62.423	
5.56	42	62.423	
6.11	43	62.422	
6.67	44	62.420	
7.22	45	62.419	0.99993
10.00	50	62.408	1.00015
12.78	55	62.390	1.00038
15.56	60	62.366	1.00074
16.67	62	62.355	
18.33	65	62.336	1.00119
21.11	70	62.300	1.00160
23.89	75	62.261	1.00239
26.67	80	62.217	1.00299
29.44	85	62.169	1.00379
32.22	90	62.118	1.00459
35.00	95	62.061	1.00554
37.78	100	61.998	1.00639
40.56	105	61.933	1.00739
43.33	110	61.865	1.00889
46.11	115	61.794	1.00989
48.89	120	61.719	1.01139
51.76	125	61.638	1.01239
54.44	130	61.555	1.01390
57.22	135	61.473	1.01539
60.00	140	61.386	1.01690
62.78	145	61.296	1.01839
65.56	150	61.203	1.01989
68.33	155	61.106	1.02164
71.11	160	61.006	1.02340
73.89	165	60.904	1.02589
76.67	170	60.800	1.02690
82.22	180	60.587	1.03100
87.78	190	60.366	1.03500
93.33	200	60.136	1.03889
98.89	210	59.894	1.04340
100	212	59.760	1.04440

finally escapes by explosion. In some cases the explosions are of great force.

A very high degree of heat is required to pop corn in a satisfactory manner. This causes most of the cells to explode simultaneously. The grains of the corn are literally turned inside out, and are transformed into a relatively large mass of snow-white starch.

Why Ice Floats.—When water becomes warmer than 39° it will rise to the top of a lake because it has also become lighter. This

Boiling water	at	212° F.	weighs 59.7 lbs. per cu. ft.
Water	at	32° F.	weighs 62.4 lbs. per cu. ft.
Ice	at	32° F.	weighs 57.5 lbs. per cu. ft.

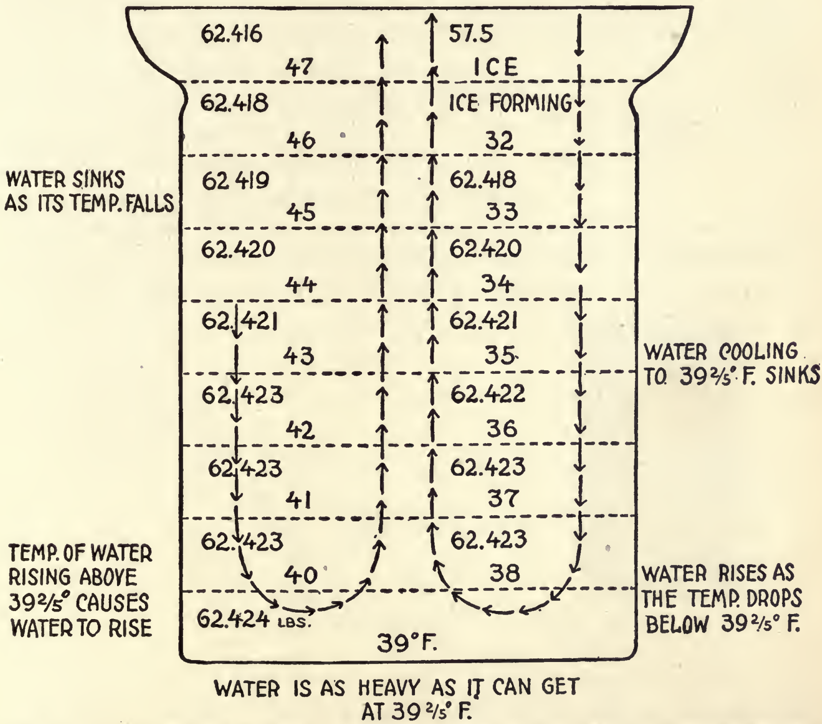


Fig. 89.—Why would ice float in boiling water? What is the difference between the weight of ice at 32° F. and water at 32° F.? At what temperatures is water the lightest? At what other temperature is the weight of water about the same as that of boiling water?

is also true of water which becomes colder than 39°. Hence, in deep lakes the water will seldom reach a temperature below or above 39° F. at the bottom.

It will be easily seen by the diagram that water at 34° F. and water at 44° F. have the same weight. What other degrees have corresponding weights? Water when freezing expands so rapidly that a cubic foot of water at freezing point 32° F., changing from water into ice at 32° F., changes weight from 62.416 pounds to 57.5 pounds per cubic foot. That is, ice weighs about 5 pounds less per cubic foot than water.

Fig. 90.—When all the water in the lake reaches the temperature of 39.2° F., it is as heavy as it will become by loss of heat. As the water near the surface continues to lose its heat, it grows lighter and remains at the surface until changed into ice.

If this expansion did not occur, ice would not float, but would sink to the bottom of our lakes and rivers, freezing solid all bodies of fresh water. It would be impossible to get heat enough even in the hottest parts of the earth to thaw out the lakes during the summer.

Expansion of Metals and Solids.—With few exceptions nearly all metals and solids expand with heat. Telephone and telegraph

Fig. 91.—Why has the top of the bottle been forced out?

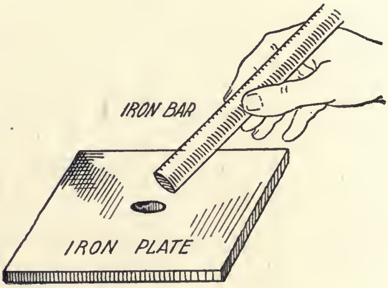


Fig. 92

wires sag more during a hot day than during a cold day because of the extra length caused by expansion. A mile of copper wire will be 100 inches longer on a hot day in summer than on a cold day in winter, and a mile of aluminum wire will expand 200 inches. The

only material which does not expand with heat is rubber, which shortens; however, its volume increases.

Experiment to Show Expansion.—Through an iron or brass bar drill a hole just large enough to allow a rod of the same material to pass through. Heat the rod until it will no longer pass through the hole. Fig. 92.

Melting Substances.—Most substances expand when melting and contract when changing into a solid. However, cast iron, type metal and water are examples of substances which contract on melting and expand when solidifying.

Difference in the Rate of Expansion of Different Metals.—All substances do not expand at the same rate. If a piece of iron and a piece of brass be riveted together to form a compound bar, as shown in the illustration, and heated, the bar will form an arc and become straight upon cooling.

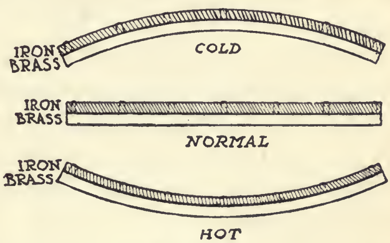


Fig. 93.

Why has the bar curved toward the iron side when hot?

Why has the bar curved toward the brass side when cold?

The different rates of expansion are called the coefficients of expansion of the respective metals.

Coefficient of expansion means the amount the substance will expand if heated $1\frac{4}{5}$° F. or 1° C.

Iron	.000011	Zinc	.000029
Brass	.000018	Pine	.000006
Glass	.000009	Marble	.000008
Platinum	.000009	Copper	.000017
Aluminum	.000023	Tin	.000022
Quartz	.0000005		

Expansion in Incandescent Lamps.—One of the metals that can be used to connect the filament of an incandescent lamp through the glass is platinum, since platinum and glass expand practically the same amount on being heated. (See table.) The platinum is sealed into the glass hot; the wire and glass contract equally,

making a tight joint whether the bulb is hot or cold, thus allowing no air to reach the filament. An alloy of iron and molybdenum is also used.

Examine the place where the wires pass through the glass of an electric light bulb.

Questions

1. How much does the air expand in your room when the temperature is raised from freezing point to normal temperature?

2. Why does the thermometer drop when first placed in hot water?

3. Why do pipes burst when freezing?

4. Why do people say pipes burst when they "thaw" out?

5. Why do fish migrate into deep water during warm weather?

6. If a tank containing 1000 gallons of water were heated from freezing point to boiling, how many gallons of water would there be in the tank?

7. Was any money saved by the man who kept his gas meter 10° cooler than the surrounding atmosphere by placing over the meter a wet cloth extending from a tub of water?

8. Why do pipes snap and crackle when the steam is first turned on?

9. What are expansion joints? Why are they used on steam and hot-water pipes?

10. Why do little bubbles of air collect on the inside of a glass of water standing in a warm room?

11. Why are eggs which are to be used in an angel cake beaten in a cold place?

12. Why do thick glass tumblers break when hot water is poured into them?

13. Why do thin glasses seldom break?

14. Why does not the filling of our teeth fall out when we eat ice cream?

15. Why does the dentist use a composition of silver, mercury, tin, etc., for so-called silver filling?

16. Why does paper or bread curl up when heated on one side?

17. Why does popcorn pop?

18. Why will it pop better if placed in a cold damp place in the

ice box, and then poured into a pan which contains a spoonful of hot melted lard?

19. How does the weight of a cubic foot of water at 34° F. compare with the weight of a cubic foot of water at 44° F., at 38° F., at 90° F.?

20. Boiled water contains no air. Why will boiled water upon freezing cause a pipe to burst more quickly than water which has not been boiled?

MEASURING OF HEAT

Thermometers.—Since some metals and liquids expand equally for an equal amount of heating, the amount of expansion has been used to measure temperature. The usual kind of thermometer has a glass bulb blown on the end of a fine-bore glass tube. The bulb and part of the tube are filled with mercury, and the top sealed after the air has been removed. Mercury is used for high temperatures since it freezes at 38° F. and boils at 647.6° F. Alcohol thermometers are invariably used in cold climates, for this liquid freezes at 202° F. below zero and boils at 173.5° F.

There are three types of thermometers used. The Fahrenheit, Centigrade and the Reaumur (Rā′ō′mür). The relative values of the degrees on the different thermometers are given in the following table:

THERMOMETRIC SCALES

Data Determined.	Fahrenheit.	Centigrade.	Reaumur.
Degrees between freezing and boiling	180	100	80
Temperature at freezing point......	32	0	0
Temperature at boiling point......	212	100	80
Comparative length of degree......	1	$\frac{9}{5}$	$\frac{9}{4}$
Comparative length of degree......	$\frac{5}{9}$	1	$\frac{5}{4}$
Countries where used.............	England and America	France and Germany.	Russia

$$F. = \tfrac{9}{5}C. + 32° = \tfrac{9}{4}R. + 32°. \qquad C. = \tfrac{5}{9}(F - 32°) = \tfrac{5}{4}R.$$

History of the Thermometer.—In 1592, Galileo, an Italian, constructed the first thermometer, which was an air thermometer.

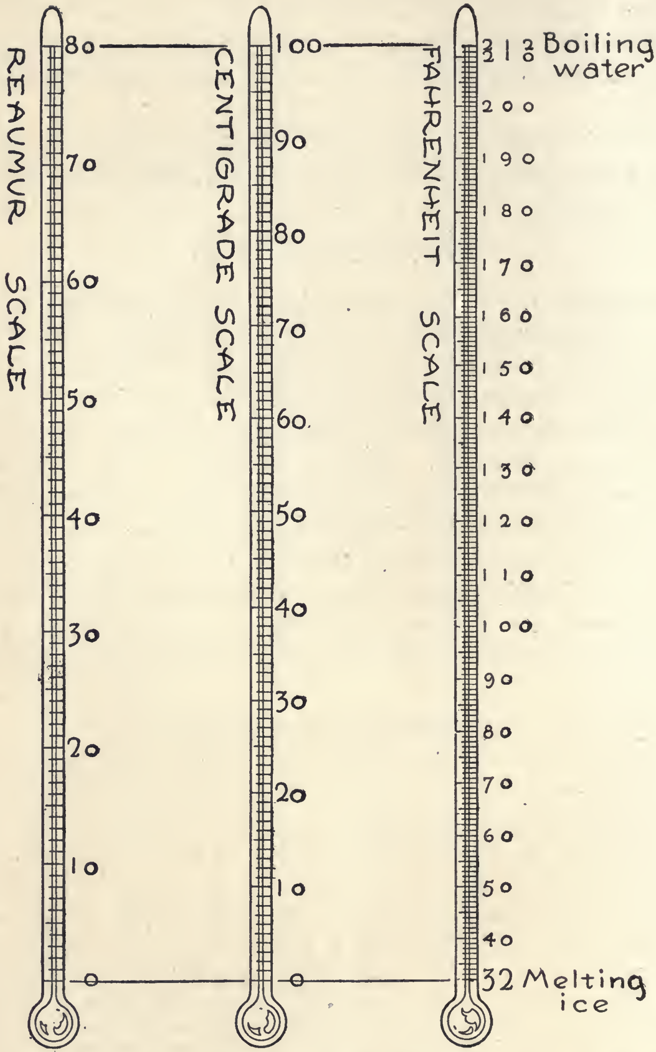


FIG. 94.—What is the temperature of your room? How does it compare with the temperatures on the Centigrade and Reaumur scales?

Previous to his time temperature was a matter of the comparison of one's personal sensations of heat.

It was not until 1700 that mercury thermometers were invented.

The instrument most widely used for scientific work is the Centigrade. This scale of reading was invented by Celsius, a Swedish physicist, in 1742. The freezing point of water is designated as zero, while the temperature of the steam rising from boiling water is 100°. The intermediate degrees are obtained by dividing the space from 0° to 100° into 100 equal parts, degrees of equal size naturally being used for temperatures above 100° and below 0°.

The thermometer which we use largely in this country is the Fahrenheit, invented in 1714 by a German of the same name. This thermometer differs from the Centigrade only in the manner of graduation. The freezing point of water is 32° and the temperature of the escaping steam 212°, the intervening space being divided into 180 equal parts, and the points above 212° and below 32° into degrees of the same size. The zero of this scale was found by noting the temperature of a mixture of equal weights of ammonium chloride and snow. Fahrenheit called this zero because he believed it to be the lowest possible temperature, i.e., the entire absence of heat.

While Fahrenheit and Centigrade are the principal thermometers utilized to-day, the Reaumur scale is used to no small extent in Germany and Russia, though now being superseded by Centigrade. The freezing point is 0° while the boiling point is 80°, with 80 equal spaces between these points. In the original Reaumur thermometer alcohol was used instead of mercury.

For extremely high and low temperatures a hydrogen gas thermometer is used, somewhat similar in principle to Galileo's original instrument for recording heat.

Use of Thermometers.—The measure of temperature is very important. People for many ages have measured heat roughly. Testing the heat of a flatiron with the moistened finger and testing the heat of the oven with a piece of paper are familiar illustrations. The thermometer on the oven door has taken the place of the paper. This is known as a metallic thermometer.

Many thousands of lives are now saved that would be sacrificed were the old unreliable method of taking temperature by

feeling the brow or the hand still in vogue. The clincial thermometer tells the nurse or family of the approaching fever.

If the thermometer registers 100° F. the fever is slight; at 102° F. the fever is rising; at 103° F. it is serious; at 106° F. the

FIG. 95.—A clinical thermometer in a case.

condition is alarming, as over this temperature the disease may prove fatal.

Bath thermometers are useful, as one may regulate the temperature of the bath to that best suited to the individual need.

FIG. 96.—Bath thermometer.

Cool bath, 66° F.; cold bath, lower than 60° F.; temperate bath, 78° F.; tepid bath, 86° F.; normal temperature bath, 98° F.; hot bath, 105° F. Often a normal temperature bath (98° F.) is a remedy for insomnia if the body is submerged in the warm water and allowed to remain until a feeling of drowsiness comes on.

Another highly important use of the thermometer is for the home. No home should be without a reliable thermometer. An ideal temperature for indoors is 68° F. If the temperature rises to 75°, we are living in a room which is too warm, the air of which is probably unfit for respiration.

Temperature.—Temperature is familiar to all. Certain fixed temperatures serve as starting points. The point most familiar is the temperature of the body, which is about 98.6° F. Objects are said to be "warm" "hot," "cool," or "cold," compared with the body temperature. We say a thing feels cold to us when it is colder than the temperature of the body, and warm to us when it is warmer than the temperature of the body.

With reptiles and cold-blooded animals the standard is different, and objects which feel cold to us may feel warm to the snake or turtle.

The lowest temperature obtainable is called absolute zero. This would be a point 459.6° below zero Fahrenheit, or 273.1° below zero Centigrade. At this temperature no more heat would be present in a body.

This simple form of thermometer gives indications of existing temperatures. In sick-rooms, greenhouses and many other places, it is interesting and sometimes necessary to have a knowledge of what the temperature has been. For this purpose a thermometer capable of giving maximum and minimum temperatures is used.

The creosote in the tube in the center expands when the temperature increases, driving the quicksilver down on the left-hand side and up on the right-hand side, thus increasing the air pressure in the right-hand bulb. As the right-hand side shows an increase in its scale reading it is called the "Heat" or "Maximum" side of the tube.

If the temperature lessens, the creosote will contract so that the quicksilver will fall on the "Heat" side and rise on the "Cold" or "Minimum" side, which shows the thermometer scale decreasing.

Indices are carefully made and inserted in the tubes above the levels of the quicksilver which can be used to indicate the highest and lowest points the thermometer has reached since its last setting.

The index is a miniature glass bottle with a small piece of steel wire inside it. Steel is used so that the index can be raised or lowered by means of a magnet which can be moved up and down in front of the tube.

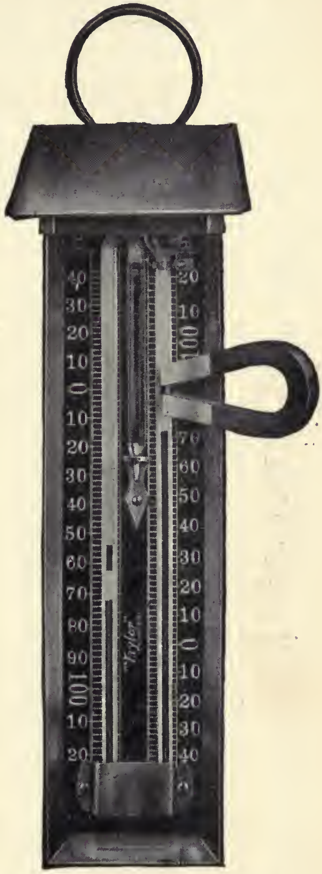


FIG. 97.—Maximum and Minimum Thermometer.

A Chart of the Various Temperatures from the Lowest Obtained to that of the Stars.

FAHRENHEIT		CENTIGRADE
	up to 90,000°F. STARS up to 50,000°C.	
	10,800°F. SUN 6000°C.	6000
10000		
9000		5000
8000		
7000		4000
	6700°F. ARC LAMP 3700°C.	
6000		
	5430°F. TUNGSTEN MELTS 3000°C.	3000
	5100°F. MAGNESIA MELTS 2800°C.	
5000		
	4650°F. LIME MELTS 2570°C.	
4000		
	3800°F. TUNGSTEN LAMP (1.0 watt per candle) 2100°C.	
	3720°F. ALUMINA MELTS 2050°C.	2000
	3550°F. CARBON FILAMENT LAMP (3.1 watts per candle) 1950°C.	
	3191°F. PLATINUM MELTS 1755°C.	
3000	2900°–3150°F. FIRE CLAY BRICK MELTS 1600°–1730°C.	
	2646°F. NICKEL MELTS 1452°C.	
	2000°–2200°F. CAST IRON MELTS 1100°–1200°C.	
2000	1981°.5F. COPPER MELTS 1083°C.	
	1945°.5F. GOLD MELTS 1063°C.	
	1761°F. SILVER MELTS 960°.5C.	1000
1000	1217?.°F. ALUMINUM MELTS 658°.7C.	
	786°.9F. ZINC MELTS 419°.4C.	
	621°.1F. LEAD MELTS 327°.4C.	
	449°.4F. TIN MELTS 231°.9C.	
	212°F. WATER BOILS 100°.0C.	
0	32°F. ICE MELTS—WATER FREEZES 0°.0C.	0
	–38°F. MERCURY FREEZES –38°.9C.	
	–303° to –314°F. AIR LIQUEFIES –186° to –192°C.	
–459°.6F ABSOLUTE	–457°.3F. LOWEST POINT REACHED –271°.8C.	ZERO –273°.1C.

TABLE OF USEFUL TEMPERATURES

	Degrees Centigrade.	Degrees Fahrenheit.
Melting point of aluminum	659	1218
Melting point of lead	327	621
Oven temperatures for baking:		
Biscuit and pastry	232 287	450 550
Sponge cake, bread, gingerbread, plain cake, and cookies	177 204	350 400
Parker House rolls, popovers, and biscuits	204 232	400 450
Custards, meringues, pies, puddings, etc	121 177	250 350
Melting point of common soft salt	185	365
Plain sugar sirup:		
For almond and walnut brittle	157	315
For clear brittle candies, peanut brittle, etc	154	310
For taffy and like hard candies to be pulled	149	300
For fudge and other candies of like nature	115	240
For fondant candies	113 115	236 240
For sirup, 11 pounds to the gallon	104	219
Water boils at normal pressure	100	212
Pasteurizing milk (flask process)	71	160
Pasteurizing milk	63	145
High fever, temperature measured as above	40.6	105
Incubator temperature	39.4	103
Normal temperature of the human body determined by thermometer under the tongue	37	98.6
Rooms where occupants are not exercising	20 21	68 70
Ripening of cream	18 21	65 70
Gymnasiums, or rooms where occupants are actively engaged in physical work or exercises	13	55
Churning	11 17	52 62
Household refrigerator	7 13	45 55
Danger of frost	+ 4	39
Water freezes	0	32
Freezing cold storage	−18 0	0 + 32
Mercury freezes	−39	− 38

Determination of Temperature from Character of Emitted Light. —The colors given below are for approximate determination of the temperature of a furnace; however, the table may be used for all kinds of combustibles under similar conditions.

Character of Emitted Light.	Temperature Degrees Fahrenheit.	Temperature Degrees Centigrade.
Dark red, blood red, low red	1050	?
Dark cherry red	1175	?
Cherry, full red	1375	?
Light cherry, bright cherry, light red	1550	?
Orange	1650	?
Light orange	1725	?
Yellow	1825	?
Light yellow	1975	?
White	2200	?

Temperatures are sometimes determined by bodies that shine by incandescent light and not by actual combustion.

DIFFERENT COLORS OF IRON CAUSED BY HEAT

Color.	Degrees Centigrade.	Degrees Fahrenheit.
Pale yellow	210	410
Dull yellow	221	430
Crimson	256	493
Violet, purple and dull blue; between 261° and 370° C. it passes to bright blue, to sea green, and then the color disappears	261 370	502 680
Commences to be covered with a light coating of oxide, loses a good deal of its hardness, becomes more impressible by the hammer, and can be twisted with ease	500	932
Becomes nascent red	525	977
Somber red	700	1292
Nascent cherry	800	1472
Cherry	900	1657
Bright cherry	1000	1832
Dull orange	1100	2012
Bright orange	1200	2192
White	1300	2372
Brilliant white, welding heat	1400	2552
Dazzling white	1500 1600	2732 2912

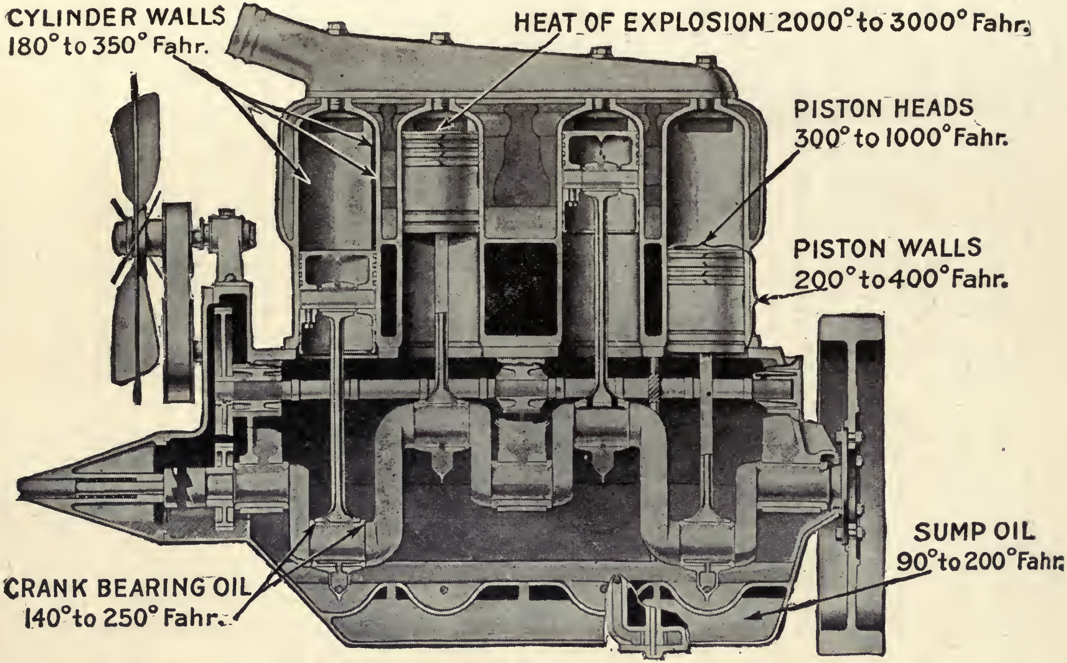


FIG. 98.—Temperatures of a working gasoline engine. Why is a fan necessary on an automobile engine? By what method is the heat removed from the engine? Why is water used around the cylinders? Why should oil which burns at a high temperature be used for lubrication?

Temperature, Btu. and Calorie.—The word **temperature** is a word of Greek origin meaning, "to measure heat." It, however, does not mean to measure the amount of heat but the degree of heat. Every one knows that a barrel of water at 60° F. requires more heat to heat it to 80° F. than does a quart of water, from 60° F. to 80° F.; in fact, it would require 125 times as much heat to heat the water in the barrel. The degree of heat is measured by the thermometer, and the amount of heat by the B.T.U. (British Thermal Unit). From now on this unit will be written "Btu."

The amount of heat required to heat 1 **pound of water** 1° F. is called a **Btu.** This unit is used in our country and in England. In many of the other countries of the world heat is measured by the **calorie,** which means the amount of heat required to heat **1 gram of water** 1° C.

Place a pound of water in a large dish and 1 gram of water in an evaporating dish. Heat both to boiling point after taking the temperature of the water in both dishes. What thermometers would you use? How many Btu. would be required to heat the pound of water? How many calories to heat the gram of water? How many calories would be required to heat the pound of water to boiling?

Latent Heat.—Ice has a temperature of 32° F., and ice water, also, has the same temperature. Some people might think the ice was colder than the water. If a piece of ice is placed in a dish and allowed to melt, the temperature of the mixture remains about 32° F. or 0° C. until the ice is melted. This shows that a great deal of heat is used to melt the ice without raising the temperature. The heat which is used to melt the ice is called **latent heat** (hidden heat).

Ice melting in the refrigerator takes heat from the food and air of the box. This heat is in the water, and is removed from the box as the water runs out. When water freezes, large quantities of heat are given off. For every pound of water which freezes, 143 Btu. are released to the surrounding atmosphere, and the same amount of Btu. is taken from the atmosphere for each pound of ice melted.

Put a small amount of ice water in an evaporating dish. Heat the water to boiling point, noting the time required. Boil the water until it has all changed to steam, noting the time required.

The time required to boil the water away will be about five times as long as to heat the water from freezing point to boiling. That is to say, the steam has over five times as much heat in it as boiling water, although the temperature of steam and boiling water is the same (about 212° F.).

To change 1 pound of water into steam requires 970 Btu., and to raise the temperature of 1 pound of water from freezing point to boiling point requires 180 Btu. Again, the heat required to change a liquid into a gas is called latent heat. Heat which will affect the thermometer is called sensible heat.

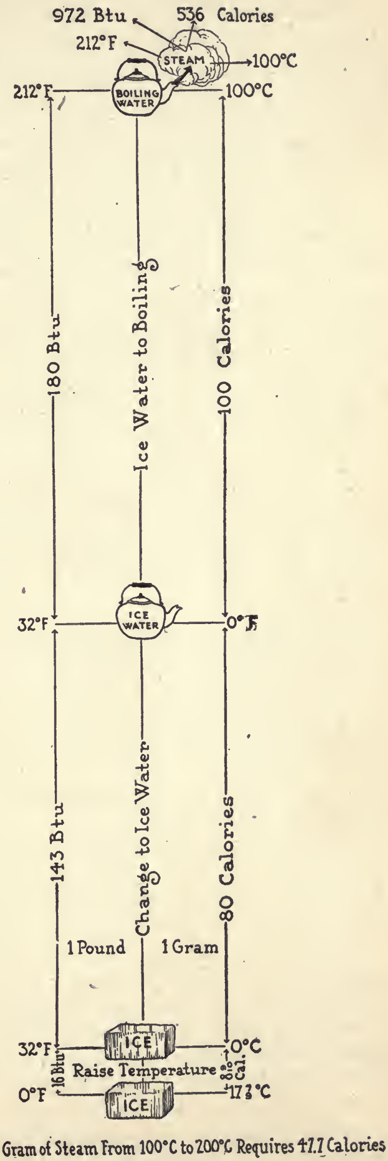


FIG. 99.—How much heat is used to melt ice? What is the temperature of the ice while it is melting? What is the temperature of the water after the ice is melted? How much more heat has a pound of water at 32° F. than ice at 32° F.? How much more heat has a pound of steam at 212° F. than a pound of water at 212° F.? How hot could you heat a half a pound of water at 32° F. with the same heat that was used to melt a pound of ice?

Heat Produced by Solidification.—Tubs of water are sometimes placed in cellars to prevent vegetables from freezing. As the temperature of the cellar falls, the water begins to freeze first. In so doing it gives out heat enough to prevent the air from falling as far below the freezing point as it otherwise would. Heat continues to be given out by the water as long as it is freezing.

It is possible to observe these changes more easily in some other substances than it is in ice. When we melt substances and then allow them to crystallize, they give out the same amount of heat which is needed to melt the crystal. This heat, which becomes apparent in solidification, makes the substance warm the containing vessel and surrounding object. Observe the change in temperature before, during and after the crystallization process in some melted hyposulphite or soda (" hypo ").

(*a*) Fill a test tube half full of crystals of "hypo," saving out a small crystal for use later. Support the test tube by means of a wire holder in the top of a boiler, and heat until the "hypo" is melted and the liquid has cleared up.

(*b*) When the "hypo" is melted, fasten the test tube in the *lower* clamp on the ring stand. Fasten a thermometer in the upper clamp and adjust so that the bulb is well down in the liquid "hypo." Fasten the thermometer in this position, and do not afterward disturb either tube or thermometer.

(*c*) Stand a glass of cold water on a ring of the ring stand, and raise it until the liquid "hypo" in the test tube is entirely surrounded by the water. Immediately begin to read and record the temperature shown by the thermometer *every half minute.* (One student should hold the watch while the other watches the thermometer.)

(*d*) When the temperature of the liquid "hypo" has fallen to 55° F. or below, drop a small crystal of "hypo" into the liquid "hypo" in the test tube. Continue reading the temperature every half minute as before, and also observe closely what happens in the liquid "hypo" after the crystal is dropped in.

(*e*) Continue the reading until the "hypo" has solidified and the temperature is again falling steadily or has become stationary. Do not attempt to pull the thermometer out of the solidified "hypo," but put the test tube, thermometer and all, in some hot water. As soon as the "hypo" is melted, remove the thermometer and wash all the material carefully.

What would you consider the freezing point of "hypo"?

What happens when solidification begins? Why?

What would be the result if "hypo" or similar material were used in a bottle for a chemical hot water bottle?

Specific Heat.—Not all substances require the same number of Btu. to heat 1 pound of the substance 1° F. or 1 gram of it 1° C. The amount of heat required to heat 1 gram of any substance 1° C. is called the specific heat of that substance. It takes less heat to heat 1 pound of tin 10° than it does to heat 1 pound of water.

It requires very little heat to heat mercury, which makes it a valuable substance for thermometers.

TABLE OF SPECIFIC HEAT

Water	1.00	Sand	.19
Copper	.091	Olive oil	.31
Alcohol	.62	Wood	.65
Iron	.113	Lead	.031
Soapstone	.21	Glycerin	.55
Glass	.198	Marble	.21
Aluminum	.214	Salt	.17
Tin	.055	Brick	.2
Limestone	.217	Marble	.215
Mercury	.033	Air	.238

From the table it will be seen why soapstone discs are used in fireless cookers in place of iron discs.

Experiment to Show Specific Heat.—Heat in boiling water several pieces of different metals of the same weight. Take several cans of the same size and material and containing each the same amount of water at a uniform temperature. Into each can drop a piece of metal, and see which heats the water the most. That metal has evidently the highest specific heat of the metals used.

Melting and Solidifying.—Different substances melt at different temperatures. The **melting** point is called the **fusion** point. The reverse of this process is called freezing or solidifying. Nearly all substances remain at the temperature of the melting point until completely changed into a liquid. A few substances, such as sealing wax and butter, continue to become warmer as they melt.

Impurities affect the melting point. Salt is often used to melt ice, as the presence of salt causes the ice to melt at a lower temperature. The use of salt in the ice cream freezer is readily understood, since the temperature of the melting solution is about 32° F. below freezing point.

Impurities in water, such as salt, produce a low freezing point.

TABLE OF MELTING POINTS

	Temperature Centigrade.	Temperature Fahrenheit.
Alcohol	−130	
Mercury	−38.8	
Ice	0	32
Butter	33	91.4
Lard	33	
Paraffin	38–52	?
Fusible metals	70	
Sulphur	114	
Solder	190	?
Tin	232	
Lead	328	
Zinc	419	
Aluminum	655	
Silver	955	
Gold	1060	
Copper	1068	
Iron	1100	
Platinum	1730	
Tungsten	2800	6072
Tantalum	2300	4172

Alloys are usually made of two or more metals. The chief use of an alloy is for soldering. Lead pipes are mended by an alloy made of one-half tin and one-half lead. The melting point of this solder is 374° F., while the melting point of lead is 682° F.

An alloy mixture of bismuth, 7 parts, lead, 4 parts, tin, 2 parts, and cadmium, 1 part, melts at a temperature of 158° F. A teaspoon made from this alloy would melt in a very hot cup of coffee.

Automatic fire sprinklers use an alloy which melts at a low temperature. Pipes near the ceiling of the rooms in many buildings are fitted with automatic fire sprinklers as a protection against fire. The heat of the fire melts a plug and allows the water to be forced out into the room.

Plugs for boilers and electric fuses are made of alloys which melt easily.

Questions

1. Why do objects, which ordinarily feel cold to us, often feel warm when our hands are cold?

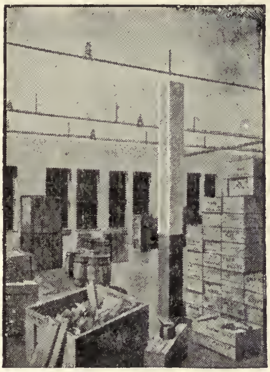


Fig. 100.—Pipes on the ceiling are provided with automatic sprinklers.

Fig. 101.—The heat of the fire melts the alloy.

Fig. 102.—The water is forced on the fire.

Fig. 103.—Such devices may prevent great losses.

2. When is a pipe hot, warm, cool, and cold?

3. Why do we blow on our soup to cool it, and on our hands to warm them?

4. Why is it poor policy to cover ice in a refrigerator with paper?

5. Why do vegetable men often place tubs of water near their vegetables to keep them from freezing?

6. Why will running water seldom freeze?

7. Why does the bottom of a kettle never melt when water is in it?

8. Why is water used in the radiator of an automobile?

9. Why will steam heat a room more quickly than hot water?

10. Why is the air over a lake warmer when the water is freezing than when the ice is melting?

11. Why is it warmer during a thunder storm than directly after the storm?

12. Why is alcohol used in the radiator of an automobile during winter time?

14. Why will glycerin keep frost off the windows?

15. Why do two pieces of ice stick after they have been squeezed together?

16. Why is a burn from steam at 212° F. so much more severe than a burn from boiling water at 212° F.?

17. Why are hot-water bottles better for warming a bed than soapstone discs or flatirons?

18. Why should thermometers for measuring the temperature of a room be placed about 4 feet from the floor, away from a window or door, and on a wall which is not exposed to the outside air?

19. Why are steam boilers fitted with "alloy plugs"?

20. Why do not plumbers use a piece of lead to mend a lead pipe?

21. What is the temperature of the body in degrees C.?

22. What is the temperature of the schoolroom in degrees C.?

23. Why does the water in fruit and vegetables freeze less easily than water in pans?

24. How many Btu. of heat will be taken from an ice box for each pound of ice melted if the temperature of the water coming from the drain is 52° F.?

25. What parts of Chapter V do you consider very important? Why?

CHAPTER VI

OXIDATION AND ITS RELATION TO LIFE

BURNING

The Discovery of Fire.—There was a time in the history of the race when fire was not known. There are many ways in which it may have been discovered. It may have been from lightning, from volcanoes, or from oil-wells, which have often burned for hundreds of years after being set on fire.

Fire has done much to advance civilization. The primitive savage learned to cook his food, to get warmth for his crude home, and to have a light as a protection against the long, cold nights when wild beasts were on all sides ready to devour him.

Next, fire became a thing of interest in the home. People gathered around the hearthstone, and were taught by its influence to become more social. To-day the whole social world owes a great deal to fire and its resultant forces,—steam, which furnishes power for our boats, trains, and lighting systems, and heat, which is so important in every walk of life.

Cause of Burning.—Place a lighted candle in a dish containing about 1 inch of water. Invert over the candle a tall olive bottle, standing in the water.

The water will gradually rise in the bottle a few inches and the candle will go out.

Something has caused a partial vacuum in the bottle, thus allowing the water to be pushed up into the bottle. Something which caused the candle to burn seems to have disappeared, since the candle went out before the vacuum was complete enough to raise the water to the level of the flame. The part of the air which seems to have disappeared, and which caused the candle to burn, was oxygen.

Experiment with Oxygen.—Fill a deep "cake tin" nearly full of water. Make a zinc shelf to this tin by bending a zinc strip about 3 or 4 inches wide

so as to allow the shelf inside to be about half as high as the sides of the cake tin. Drill a hole through the center of the shelf and two small holes on each side of the center hole. Fit a one-hole rubber stopper through the hole. Extend a glass or metal funnel through the stopper so that the bowl of the funnel is toward the bottom of the dish. The stem of the funnel must be short enough to be covered with water. All bottles inverted on this shelf must have the neck of the bottle extending under water about ½ inch.

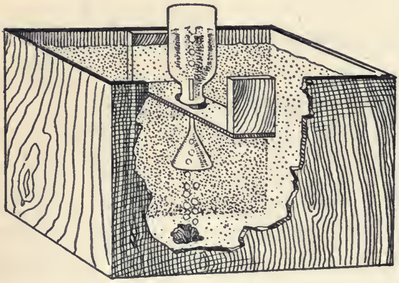


FIG. 104.

Fill two bottles with water. Cover each with a piece of glass and invert on the shelf of the cake tin, which we now call a *pneumatic trough*. Remove the glass covers, and be sure the bottles are full of water, and all air bubbles removed. Place under the funnel (called a *bell*) a small piece of fused **sodium peroxide.** The gas which rises to replace the water is **oxygen.**

The two holes will allow the water to escape quickly from the inverted bottles as the oxygen enters.

Light a soft wood splinter. After it has burned a moment, blow it out. A small spark will glow on the end of the splinter. Insert the splinter in the bottle of oxygen while the spark is still glowing. What happens will show something about the power of oxygen to make things burn. The oxygen itself does not burn, as the splinter may be removed, blown out, and reinserted several times, taking fire each time without setting the gas (oxygen) on fire.

So active is this gas that iron wire may be made to burn in it. Insert into the bottle of oxygen a piece of picture wire on which there is a little burning sulphur. The wire should burn brilliantly.

Amount of Oxygen in the Air.—It was seen from the experiment with the candle under the bottle that air is not made up entirely of oxygen. There was much air in the bottle after the candle went out. About one-fifth of the air is oxygen. The remaining part of the air is chiefly nitrogen, water and dust. A small amount of a gas known as Argon is also present. **Nitrogen** is a gas which will not

burn or make things burn. This gas is necessary to prevent the presence of too large a percentage of oxygen in the air.

Oxidation.—The oxygen disappeared from the air in the bottle experiment because this gas unites with any material which is burning. Whenever oxygen unites with a substance, the substance is said to **oxidize.** If the oxidation takes place very rapidly, heat and light are given off. Rapid oxidation is called **burning** or **combustion.** When the food in our body oxidizes, giving us the necessary heat to maintain life, the process is called **wet burning.** Sometimes oxygen unites so slowly with substances as to give off little heat at any one time. This process is called **slow oxidation.**

Iron rust is caused by oxygen uniting with the iron. Whenever oxygen unites with a substance, the resulting compound is called an oxide. Iron oxide, copper oxide, etc., simply means that oxygen has united with the substance.

Meats turn brown when exposed to the air. An apple which has been cut open and exposed to the air will turn dark brown, probably because the oxygen unites with the iron in the apple, forming oxides.

It is believed that nearly all the colors in nature are due to different forms of iron. Different compounds of iron give the colors of blue, green, red, and brown.

Spontaneous Combustion.—Heaps of cotton waste soaked in oil slowly oxidize, giving off heat until the heat produced raises the material to the kindling point, and fire results. Such fires are said to be caused by **spontaneous combustion.**

The Production of Light and Heat without Oxygen.—Burning, then, means a rapid combining of oxygen with other substances, usually with the production of heat and light. Unless oxygen is present, burning can not take place. Substances may glow, as in an electric light bulb. The filament becomes very hot, but does not oxidize or burn.

Scientists have come to the conclusion that there is no oxidation in the sun. The sun is really not burning up but glowing, and heat is given off by its constant shrinking. This shrinkage is supposed to be about 300 feet each year. So great is the weight of the sun, 1,980,000,000,000,000,000,000,000,000 pounds, that great quan-

tities of heat are given off because of its great pressure. The sun is about 1,300,000 times the size of the earth.

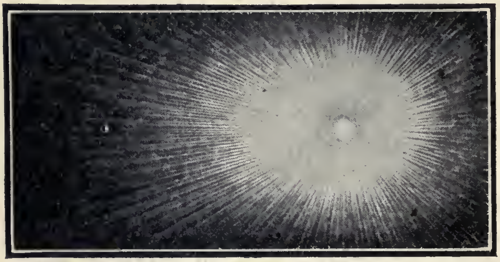


FIG. 105.—The earth's tiny share of the sun's heat.

Radium and other elements are also supposed to assist in giving off heat.

Oxygen in Other Things.—The amount of oxygen in the rocks a few feet below the surface of the earth equals the amount of oxygen in the air above them. Oxygen is found in water, food, sand, clay, gravel, wood and in the majority of substances which we use every day. It is not found free, as we find it in the air, but united with the substances.

Prevention of Oxidation.—Many methods of preventing oxygen from uniting with substances have been tried. Painting wood, iron, etc., is the usual method. Sometimes the outside of the substance is oxidized, or covered with a lacquer or shellac.

The leathery skin formed on linseed oil left exposed to the air is due to the oxygen in the air. We often use paints and oils which oxidize and form a hard substance over the material we wish to keep from the oxygen. Paint containing linseed oil, fish oil, or china oil is said to contain **drying oils.** When these oils do not oxidize rapidly enough, a **drier** is added. Certain metals, as nickel, oxidize very slowly, and are often used to cover other metals which oxidize rapidly.

Rapid oxidation or burning is often prevented by adding water, thus shutting off the supply of oxygen. The water lowers the temperature, changes to steam, or covers the material with a thin film of water and water vapor—an action which prevents oxygen from uniting with the burning material.

Water cannot be used to extinguish the flame of burning oil because the oil is lighter than water and will float on it, thus coming in contact with the air and continuing to burn.

There are some gases, like nitrogen, which do not support combustion. These gases are used in fire extinguishers, as the gas surrounds the burning material, shutting off the supply of oxygen. The fire extinguisher "Pyrene" contains **carbon tetrachloride,** a liquid

Fig. 106.

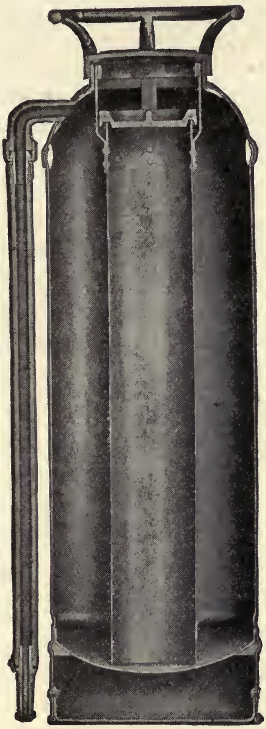


Fig. 107.

Fig. 108.

which readily changes to a gas when heated. This gas surrounds the burning object, preventing the oxygen from uniting with the material.

The ordinary fire extinguisher uses a gas called " carbon dioxide,"

which is produced by the use of sodium bicarbonate (baking soda) and sulphuric acid. Another type of this kind of fire extinguisher contains material which forms bubbles or foam. Oil fires are thus extinguished easily as the bubbles prevent air reaching the surface of the oil.

When the fire extinguisher is inverted the stopper falls out of the bottle and the sulphuric acid and baking soda come together, forming carbon dioxide and water, which are forced out of the rubber hose on the fire. Fire extinguishers should be tested from time to time to see that the acid has not deteriorated.

Experiment.—The action of carbon dioxide on a flame may be seen easily by placing in an olive bottle a few spoonfuls of baking soda, a little water and a small amount of sulphuric acid. Close the bottle with a one-hole rubber stopper through which runs a glass tube extending into an empty bottle. The bottle will soon be full of the gas generated from the first bottle. Light several candles and pour the gas over them. Try a bottle full of the gas on a Bunsen burner.

Kindling Temperature and Matches.—Substances which burn have a definite temperature at which they will start burning. Not all substances start to burn at the same temperature. Wood, phosphorus, paper, sulphur, etc., have different kindling points. The match is an example of the use of different substances with different kindling points.

Matches are made by soaking one end of a piece of wood in paraffin and then dipping this in a mixture of glue, phosphorus, and a material which gives off oxygen, such as potassium chlorate. Some matches are made of powdered glass, zinc oxide, rosin, glue and coloring matter. Safety matches have the phosphorus on the box so that the matches will not take fire inside the box.

Fig. 109.

Experiment. To Boil Water in a Paper Bag.—Take a square piece of paper and fold it so as to form a conical bag as shown in Fig. 109. Suspend the bag by strings and, pouring water into it, allow the flame of an alcohol lamp or Bunsen burner to fall on the bag, being careful to prevent the flame from touching the paper in any place where there is no water. The water can now be heated until it boils, without the paper being burned, because the paper cannot be heated much more than 212° F., and this is not sufficient to burn it, since the kindling point of paper is higher than the temperature of boiling water.

Questions

1. Why will damp hay in a barn take fire?

2. Why must one be careful not to throw in a pile waste and rags which have been used about an automobile engine?

3. Overalls which are oily will sometimes take fire if thrown in a heap on the floor and left for a long time. Why?

4. Why will hanging the oily overalls on a nail prevent spontaneous combustion?

5. Why must wood fires be arranged loosely in order to burn well?

6. Why does a bale of cotton or a pile of sawdust smolder if on fire?

7. How are fires put out on shipboard?

8. Why should a person whose clothes are on fire never run out-of-doors?

9. What is the best way of extinguishing a flame when one's clothe stake fire?

10. Why is one able to stamp out a fire?

11. Why will a burning match go out if covered with the foot?

12. Why should not water be used on an oil fire to extinguish it?

13. What is the best method of preventing oxidation of a house, iron, brass?

14. What is the best method of putting out a fire in a room?

15. What would you do if the lace curtains caught fire?

16. When one stops all night in a hotel what precautions should be taken as to fire?

17. Find out the fire requirements of your town regarding inflammable oil, fire extinguishers in public buildings, school fire drills, etc.

18. Is your school living up to the requirements? Insist that it does. This is a part of good citizenship.

GAS AS A FUEL

Parts of a Flame.—If a sheet of cardboard is held in a candle flame or gas burner, the paper will be scorched in the shape of a ring, the middle of the ring being unburned. Run a pin through a match, near the head, and place it carefully upright in the center of a Bunsen burner. Light the burner. The match will not take

fire in the colorless cone at the center of the flame. This part of the flame is made up of unburning gases. Hold a piece of glass tubing in the inner cone in such a manner as to allow the gas to run through the tubing. Light the gas outside of the flame at the other end. This inner cone is made up of unburning gas which diffuses outward to the air. Around this is a second cone in which oxygen unites with the gas, setting free small particles of carbon which are heated to "white heat." Around this second cone is a third cone, bluish in color, where complete combustion is taking place. If a large quantity of air is allowed to enter the Bunsen burner a non-luminous flame is produced, with an inner cone of unburning gas, and an outer cone of gas where complete combustion is taking place, resulting in a colorless flame.

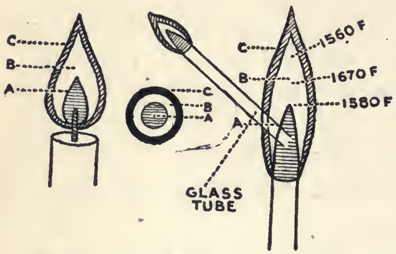


Fig. 110.—Parts of a Flame.

The Action of Wire Gauze upon Gas.—Place a piece of fine copper wire gauze over a small gas flame. It will be seen that the gas above the wire gauze does not take fire until the gauze has become red hot. Turn out the gas. Allow the gauze to cool; replace it about 1 inch above the burner, and light the gas above the gauze. The gas will burn on top of the screen and will not take fire underneath, since the heat is rapidly conducted away by the wire screen, preventing the gas from reaching the temperature of kindling point.

There are two uses made of this principle. One is in the Davy Safety Lamp in which the flame is enclosed in a screened cylinder. This enables miners to go into a mine without danger of exploding the fire damp (a gas found in mines), since the gas can burn only as fast as it can sift through the screen. A screen is also used in the Bunsen burner or mantles to prevent the gas from burning back. Often in lighting a gas light the mixture of air and gas is sufficient to cause a slight explosion which often causes the gas to take fire at the spud or base of the burner. The gauze helps to prevent the gas from taking fire at this point.

Explosions.—When air is mixed with an inflammable gas, and the temperature is raised to the kindling point of the gas, an explosion takes place. The gas expands suddenly, sometimes with force enough to blow walls or buildings apart.

There are usually two sounds to an explosion, one caused by expansion, and the other by the air rushing in. The two sounds occur so close together as to give the impression of one. If there is a large amount or a very small amount of gas present in the air, the mixture will not explode. The proportion of air to gas in an explosive mixture varies, but in general it ranges from about 5 to 12 parts of air to one part of gas.

The gas of gasoline explodes when 1.5 to 3 per cent of gas is mixed with air. Kerosene poured upon a burning fire often produces disastrous explosions because the gas and air are mixed in the right proportions. Explosions in mines are due to the same cause.

Hydrogen.—Hydrogen is a colorless, odorless gas which burns with a blue flame, if pure. The gas is found in coal, and also helps to make up many valuable compounds, such as water, hydrogen peroxide, acids, sugars, starches and many of our foods. As the gas is very light, it is of great value for filling balloons.

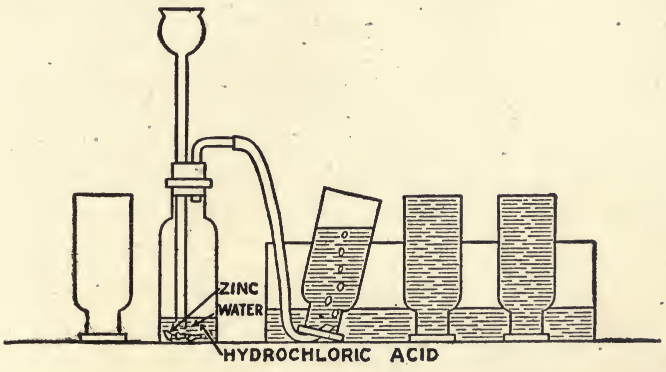


FIG. 111.

Hydrogen mixed with air is very explosive. It affords one of the best examples of a gas exploding when mixed with the correct proportion of air.

Fill one bottle full of water, another half full of water, and place only a small amount of water in a third. Arrange a gas generator as shown in the diagram. Collect the gas in the three bottles, over water. Hydrogen gas may be made by placing a small amount of zinc in the generator and adding hydrochloric acid and water.

Test each bottle with a lighted taper. Note what happens to

1. The bottle of pure hydrogen;
2. The bottle half hydrogen and half air;
3. The bottle nearly full of air and a slight amount of hydrogen.

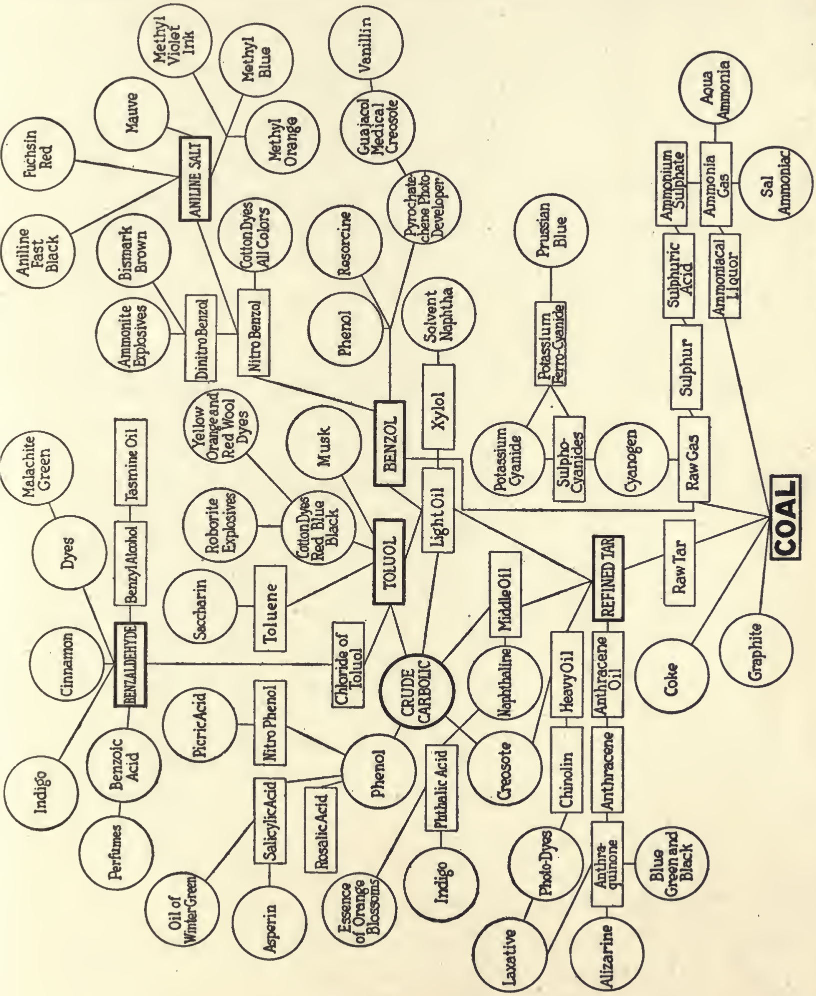
Burning of Gas.—Light a candle. After a few moments blow it out and hold a lighted match in the stream of gas a little way from the wick. The vapor will take fire, carrying the flame to the wick. This gas can be made to burn at some distance from the flame if the candle is placed in a lamp chimney which has a few sticks under the chimney to allow the air to enter. (Why?) Carefully blow out the candle, or extinguish it with a piece of glass tubing. Allow the " smoke " or " gas " to rise to the top of the chimney. Light it with a match. The flame will burn down to the wick and relight the candle. The candle may be called a little gas generator. The wax does not burn, but melts where the wick extends out of the wax. A little cup forms to hold this melted wax which is drawn up the wick by a process known as **capillarity.**

Place one end of a lump of sugar in a drop of ink. The ink will rise to the top of the sugar. Blotters absorb ink in the same way. Rough towels dry the body more quickly than smooth towels. The water rises from the subsoil to the top soil in the same manner. The liquid rises because the attraction of the little particles of the substance always pulls it up between the tiny spaces. Water will rise higher in a glass tube which has a very small hairlike bore than in one with a large bore.

When the liquid wax reaches the upper part of the wick the heat changes it to a gas and it is this gas which burns. This furnishes an excellent illustration of how gasoline burns. The gas of gasoline has been known to take fire 50 feet from a person cleaning clothes. The fire will travel along the stream of gas to the vessel containing the gasoline. The gas of gasoline is much heavier than air.

Kerosene burns just above the liquid where there is a gas and

plenty of oxygen to keep it burning. The burning takes place as fast as the kerosene changes into a gas.



Courtesy of Popular Science Monthly.

FIG. 112.—Coal is a precious mineral. Dyes, explosives, drugs, perfumes, flavors, ammonia, oils, are some of the products obtained by direct and indirect distillation of coal. With how many products of coal are you familiar?

Heat a few pieces of wood in a test tube until gas forms. Light the gas. Do the same with paper, sugar, starch and soft coal. Notice the gas burning over a wood fire in the fireplace.

Coal Gas.—Coal gas is generated from bituminous coal. The gas is used chiefly for cooking, heating and lighting.

The products obtained from a ton of good coal are about

10,000 cubic feet of gas;
1,400 pounds of coke;
120 pounds of tar;
20 gallons of ammonia.

The coke is used to heat the bituminous coal or is sold as a fuel. Tar is used for tarred paper, paint, preserving lumber and wood pavings. Benzine and gasoline are extracted from it. Oils, dyes, flavors, perfumes, material for moth balls and many other useful products are obtained from tar.

Experiment for the Preparation of Illuminating Gas.—Arrange an apparatus as shown in the illustration. In bottle *C* place some lime water, in bottle

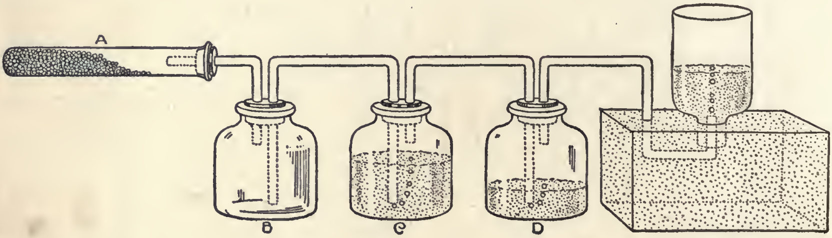


FIG. 113.

D some red litmus paper, which turns blue in the presence of ammonia, and some water for the gas to bubble through. Fill test tube *A* two-thirds full of powdered soft coal. Heat the coal in the test tube gently at first. Do not heat any one part of the tube any great length of time, as the glass will melt and the gas escape. Collect several bottles of the gas over the water and test with a match. Smell bottle *B* for tar products. Notice bottle *C* for the evidence of carbon dioxide, and the litmus paper in *D* for the presence of ammonia.

Pressure Producer Gas (Fig. 114). Pressure producer gas is made from a variety of fuels, such as bituminous coal, lignite, coke, anthracite, charcoal, sawdust, wood refuse, etc. The gas is produced under slight pressure, hence the name **pressure** producer gas.

Where the pressure producer gas plant supplies gas for an installation of 2000 H.P. or more, a by-product plant for the treatment of the tar is frequently

installed. Sulphate of ammonia and other valuable by-products are obtained from the tar; and this helps to lower the operating cost.

Fig. 114 illustrates a typical pressure producer gas plant.

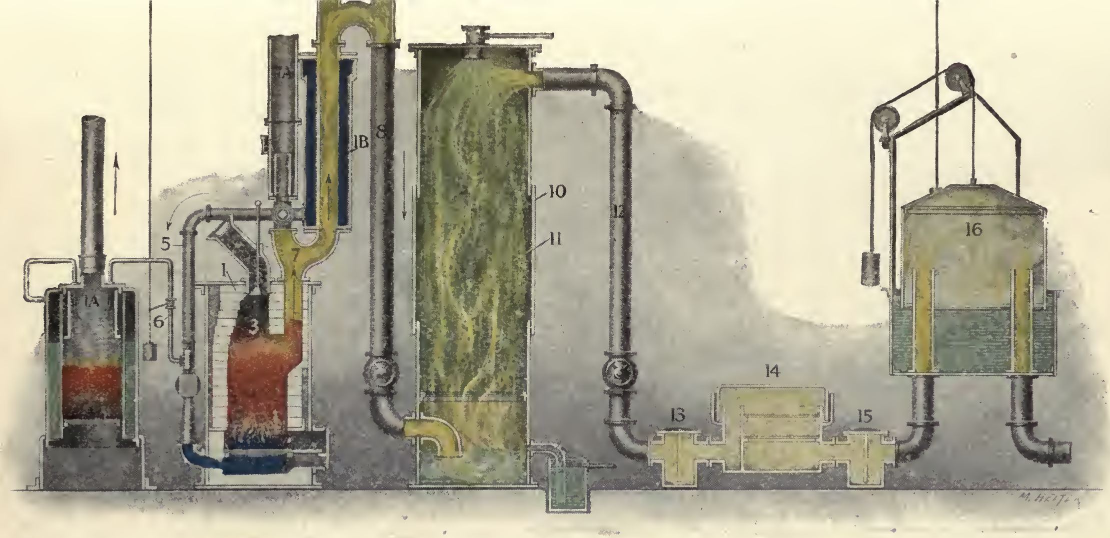


Fig. 114.

The generator (1) is filled with fuel (3). Steam is generated under slight pressure in the boiler (1*A*), flows through the pipe (6) and injects air coming from the air heater (1*B*) through pipe (5) into the bottom (2) of the generator (1).

Steam and air rise through the incandescent fuel in the generator. Gas is produced and leaves the generator (1) through the pipe (7). The warm gas passes through "down" pipe (8) and enters the scrubber (10) filled with clean coke or charcoal (11).

Cold water enters the scrubber at the top and is sprayed over the coke, cooling and purifying the rising gas. Through pipe (12) the cool gas is conducted to the tar separator (13). Occasionally a revolving tar separator is employed, which frees the gas from the greater quantity of liquid tar by centrifugal force.

The gas now passes the drying and cleaning filter (14) filled with sawdust, and after passing another tar separator (15)—sometimes used when the proportion of tar is excessive—enters the gas receiver (16) which, in large installations, is similar to the gas holders in illuminating gas works.

From the receiver (16) the gas is delivered to the gas engine or engines, as required, under a slight and constant pressure.

Measurement of Gas.—The gas used in the household is usually measured on the premises by a gas meter. In the United States and parts of Europe the so-called dry gas meter is most commonly used for this purpose.

There are a number of different types of dry gas meters in use, which, while differing considerably in external appearance and design of parts, operate on the same general principles. These general principles of operation would be understood from a description of any one of the types; and therefore only one of the most commonly used will be described.

Description of a Gas Meter.—The external appearance of the meter is well known. The interior is shown in Fig. 115, with the front and top of the meter and the top of the valve chamber removed. Essentially the meter consists of four chambers which are filled and emptied of gas by the action of the meter mechanism. The number of times this filling and emptying of the measuring chambers is repeated is indicated on the dial in cubic feet. Two of the measuring chambers are shown in the figure. One is the space between the disc (201) with attached leather diaphragm (203) and the middle partition (the plate just behind the diaphragm) of the meter. The other is the space between this same disc and diaphragm and the outside walls of the meter. The other two measuring chambers are like the two described, and are situated symmetrically to them on the opposite side of the middle partition. The filling and emptying of the measuring chambers is effected by the backward and forward movement of the discs. These discs operate in conjunction with the valves and recording mechanism (see Fig. 115) above the measuring chambers. Each set of two measuring chambers thus constitutes a kind of double-acting bellows, the number of times these are filled and emptied being a measure of the amount of gas passed through them. The power for operating this very simple and effective instrument is furnished by the pressure of the gas itself which acts upon the discs, pushing them back and forth, just as the power to operate the steam engine is furnished by the steam which presses upon the sides of the piston. The index (101) upon which the volume of gas passed is recorded is connected with

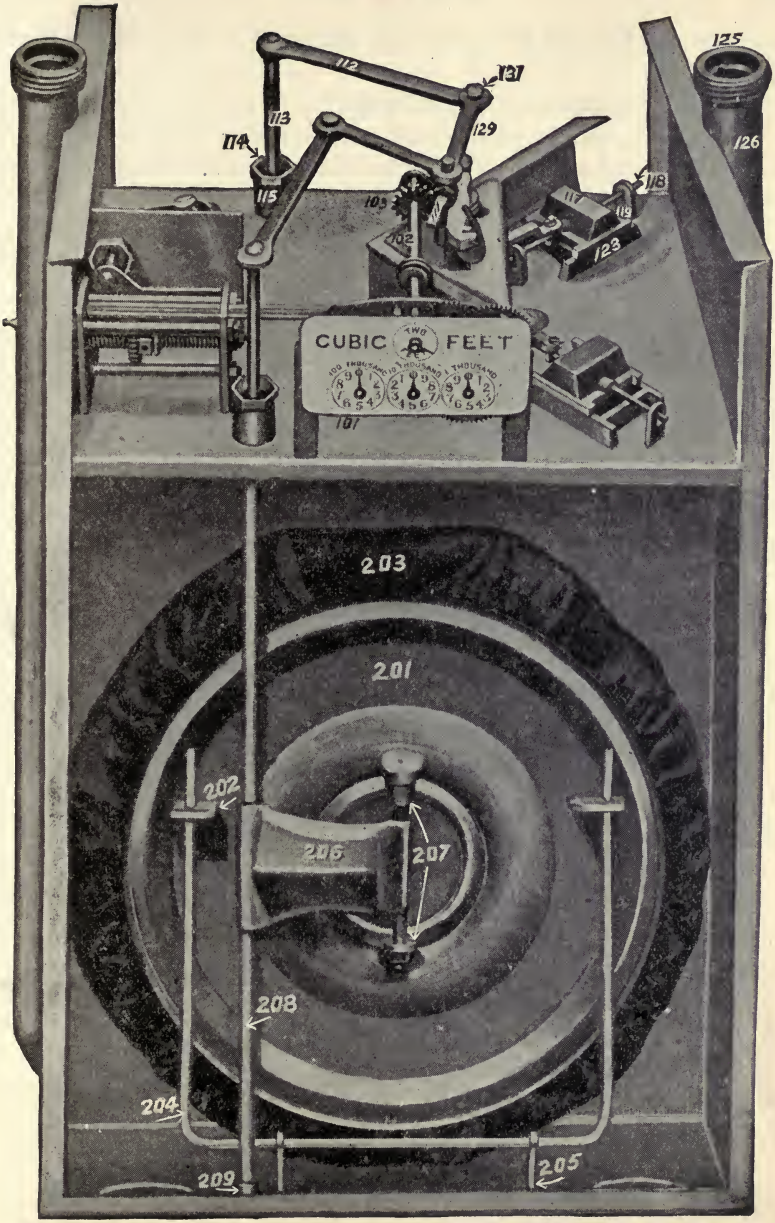


Fig. 115.—Interior of dry gas meter.

the other mechanism by means of the shaft (102) and the gear wheel (103).

Gas Meter Index and How to Read It.—Gas meters are provided with an index. The top dial of the index is called the test dial. One revolution of the test hand indicates that 2 cubic feet of gas have passed through the meter.

Of the large dials the first one at the right is usually marked

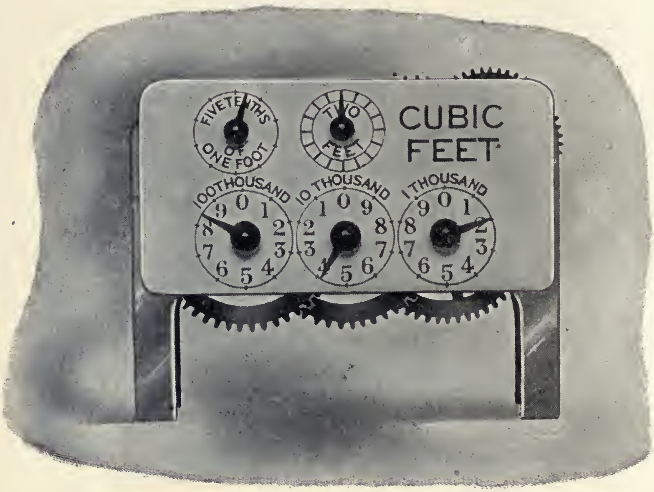


FIG. 116.

" 1 thousand." This means that during one revolution of the hand 1000 cubic feet of gas have passed through the meter. The dial is divided into ten equal parts so that the passage of the hand over each part indicates the passage of $\frac{1}{10}$ of 1000 cubic feet, or 100 cubic feet.

If the first dial is marked 1 hundred, the second dial will be marked 1 thousand, the third 10 thousand and the fourth 100 thousand, etc.

The reading of the index in the illustration is as follows:

Reading of 1 thousand dial.......	200 cubic feet
Reading of 10 thousand dial.......	4000
Reading of 100 thousand dial.......	80000
Complete reading of the meter..	84200

The amount of gas consumed for one month is obtained by subtracting the reading of the meter for the last month from the reading of the meter for the present month.

Prepayment Meters.—These meters are so constructed that one can insert a coin and receive a certain amount of gas. After this is used the meter will automatically cut off the supply of gas until another coin is inserted. Most prepayment meters are so constructed that when the gas paid for is nearly used, the supply of gas will be gradually shut off, thus giving the consumer a chance to insert another coin before his supply of gas fails entirely. The sudden shutting off of the gas supply would be not only inconvenient but dangerous, for if one should forget to turn off his burner the insertion of another coin into the meter would allow gas to escape into the home. Even when the meter does shut off the supply of gas gradually, lights go out and many accidents result. There is considerable danger in the use of prepayment gas meters.

One may easily check up the amount of gas received for the coin inserted, by reading the meter at the time the coin is inserted and rereading the meter when another coin is inserted.

Cost of Gas Consumed per Hour in Appliances.—One may easily determine the cost per hour of any gas-consuming appliance.

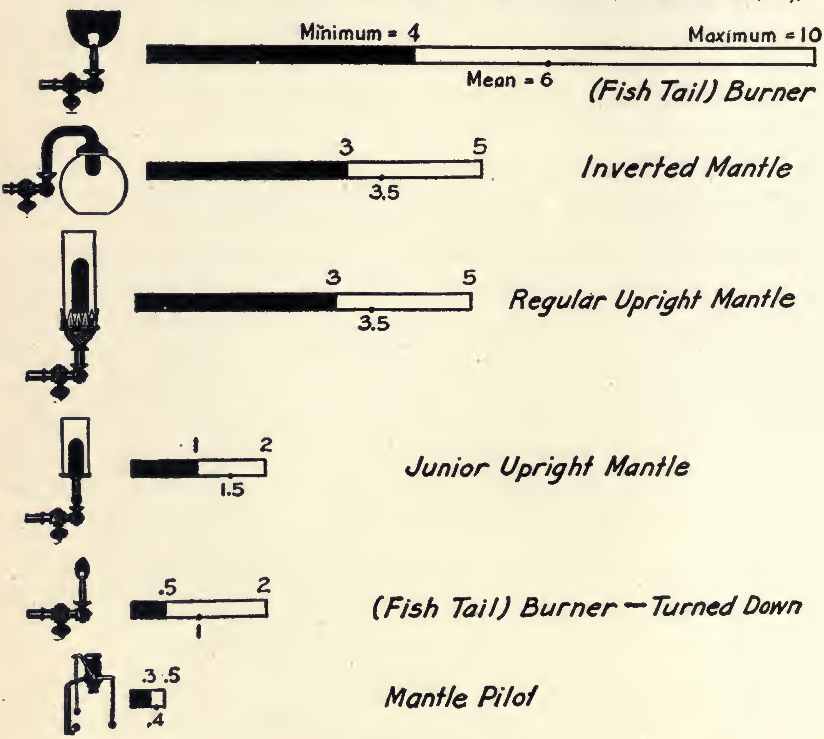
Shut off all gas appliances which consume gas through the meter. Turn on the gas for the appliance whose consumption of gas you wish to measure. Record the number of times the test dial revolves per minute. It is usually better to make several tests for several minutes and take the average.

Multiply the number of cubic feet or parts of a cubic foot by 60. Why?

Determine the cost of gas per 1000 cubic feet from your gas

company. Compute the cost of the gas consumed per hour by the gas appliance.

NUMERALS REFER TO COST PER HOUR IN MILLS (TENTHS OF A CENT).



—*Cost of gas used per hour in some common gas appliances*

Fig. 117.—What kind of gas light is most economical? What type of burner is very expensive? Why is it cheaper to buy mantles for gas lighting? The cost per hour is calculated on the basis of gas at $1 per 1000 cubic feet. The great difference between maximum and minimum costs is due to difference in size of burners and difference in the pressure of the gas supply. The mean value represents the cost under average conditions.

For a water heater of ordinary household size the gas would cost from 3 to 8 cents per hour. For larger automatic water heaters gas would cost from 10 to 25 cents per hour for the period that the

heater is in operation. The pilot-flame gas for these heaters would amount to one-tenth of a cent per hour. Room heaters require 5 to 10 cents worth of gas per hour.

Since a match costs only one-tenth mill or less, it is usually economical to turn off the gas when not in use, except for short intervals.

Error of Gas Meters.—Gas meters may be slow or fast. Gas companies are allowed to have gas meters in operation from 1 to 3 per cent slow or fast, since any measuring instrument of this character cannot be absolutely correct. This allowance is called a *tolerance.* Meters of well-conducted companies are usually within this tolerance, but it does happen that serious errors occur in gas meters, especially in districts where there are no inspectors. A consumer should check up his meter occasionally. He should read his meter as nearly as possible at the time when it is read by the gas company, and check the consumption with the gas bill, to prevent errors which may occur in the office of the company.

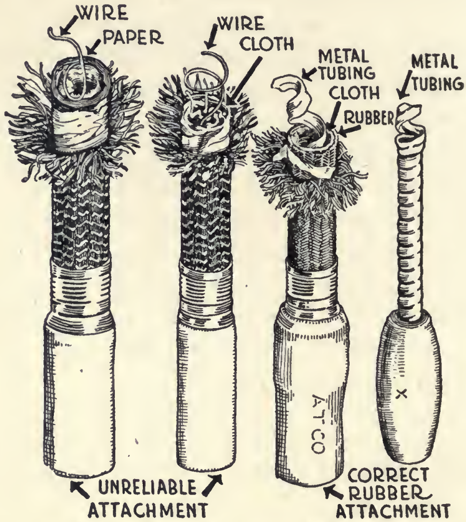
Leaks cause a great loss of gas at times. The consumer may check his meter by turning out all gas consuming appliances and watching the test dial for several minutes. If there is a leak the dial will register and the amount of gas lost per hour or day may be computed.

If a consumer's bill for a certain period of time greatly exceeds that of a previous period, it is due to one or more of the following causes:

1. An increase of gas consumption;
2. An error of the gas company in reading the meter;
3. An error in the office work;
4. A fast meter;
5. A leak.

Tubular Connections for Gas Fixtures.—Leaks are often caused by poor connecting hose or gas tubular connections. Sometimes the connecting hose is made of paper covered with cloth. If the gas is turned off at the gas appliance to which such a tubing is connected, a small amount of the gas will continually escape. Such a tubing may be easily broken or ruptured and a considerable amount of gas escape through a small opening.

Gas-connecting hose should be made of flexible metal, and, if desired, covered with silk or other types of cloth for decorative value. It costs a great deal more to purchase a reliable form of tubing, but



1. A gas-connecting hose made of paper over a wire spiral. Covered with cloth. 3c. to 5c. per foot. Very poor.

2. A gas-connecting hose made of a wire spiral. Covered with cloth, 10c. per foot. Fair.

3. A gas-connecting hose made of flexible metal. Covered with cloth and rubber. 12c. to 15c. per foot. Excellent.

4. A gas-connecting hose made of flexible metal. Uncovered.

Fig. 118.

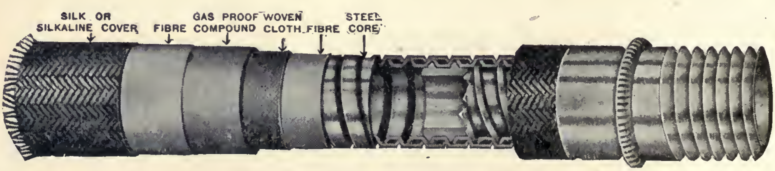


Fig. 119—Diagram of an Excellent Form of Hose.

from a hygienic standpoint, and in consideration of the length of time such a tubing will last, it is worth while.

Burners.—The Bunsen burner is chiefly used for heating, lighting and cooking.

The burner consists of three parts:

1. The barrel, a metal tube through which the gas passes. At the foot of the barrel there are two or more holes to allow air to enter.

2. A ring or device to open or close the holes.

3. A base, containing a small central gas way—called a "spud."

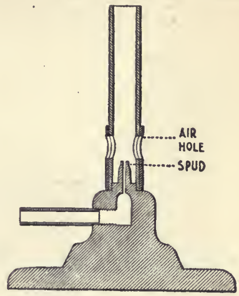


Fig. 120.

Gas enters at the base, passes through the spud and through the barrel, forming a **partial vacuum.** Air enters the holes near the base, and mixes with this gas. When the holes are partly open, air enough enters to produce a non-luminous flame. When less air enters the holes near the base, the flame will be luminous. The luminous part of the flame is due to carbon particles which are heated very hot by the burning gas. The temperature of the yellow flame is very high, causing the gas to break up and set free small particles of carbon. When air is allowed to enter at the bottom of the burner a non-luminous flame is produced, since that part of the gas from which carbon particles are set free never gets hot enough to liberate them. As the carbon particles in the luminous flame move toward the outside of the flame they come in contact with the oxygen of the air and burn up. If still less air is supplied, the carbon particles do not burn even on reaching the outer part of the flame, but appear as black smoke. A piece of cold glass or earthenware placed in the flame will cool some of the carbon particles and cause them to collect as black soot.

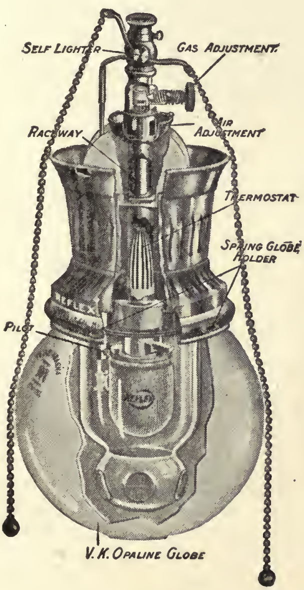


Fig. 121.

If too much air is admitted, the burner will be very noisy. If the flame is to be used for

illuminating purposes two classes of burners are in common use.

1. The fishtail burner causes the gas to separate out into a

FIG. 125.—Cotton, ramie, and artificial silk are used for manufacturing mantles.

FIG. 126.—*Knitting.* A thread of suitable size is knit into a tubular fabric on a machine modified from those used in knitting underwear. *Saturating.* The lengths of knitted fabric are placed in a suitable vessel and the so-called lighting fluid is poured over them.

FIG. 122.—Monazite sand obtained from Brazil, Australia, and from this country.

FIGS. 123 and 124.—Cerium and thorium nitrates are obtained from sand, and the cloth mantles are dipped into solutions made from these chemicals.

thin sheet so that enough air is brought in contact with the carbon to burn it, but not until it has been heated to a glowing temperature.

2. The other type of burner is used with mantles made from cloth dipped in thorium and cerium compounds.

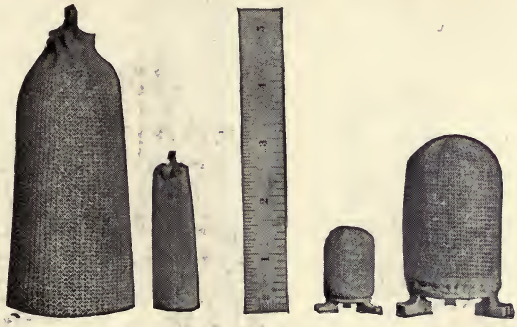


Fig. 127.—*Sewing.* The fabric is now folded in at one end and carefully plaited, and an asbestos cord drawn through to form the head and loop of the mantle. *Burning Out.* The modelled fabric is then hung on a suitable hook and ignited at the top. The thread is burned out, leaving an ash composed of the oxides of thorium and cerium. *Hardening.* After the cotton is burned out, the soft, flabby ash is placed over a blowpipe, where the gas and air are controlled in such a way as to blow it out to the form of a mantle.

The mantle is heated to a glowing temperature by the burner inside, which has sufficient air (oxygen) entering to produce a hot colorless flame.

In the first case, light is obtained from the luminous carbon particles in the flame. In the second type of burner, light is obtained from the luminous mantle, the flame itself giving no light.

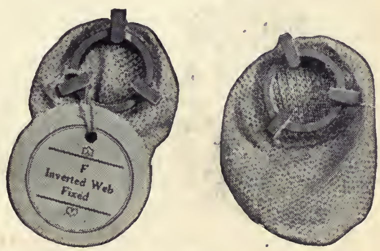


Fig. 128.—*Modelling.* After the head is made, the saturated fabric is shaped over a wooden form.

The mantle gas burner has very largely superseded the open flat flame type of gas burner for use in the general illumination of dwellings, stores, factories, etc., because it produces from two to three times more light, and consumes on the average only about one-half as much gas as the latter type of burner.

If the open flame burner is in use on your premises, do not allow the gas to burn from it with a blowing noise and a ragged flame,

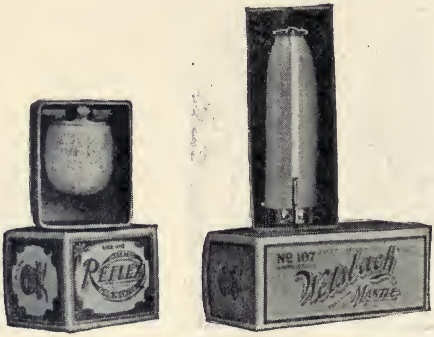


FIG. 129.—*Dipping.* In order to prepare the mantle for subsequent handling and for shipment, it is dipped into a bath of collodion and allowed to dry. *Packing.* The mantles are then passed to the packer, and packed according to the desire of the consumer. Loop mantles are suspended in paper tubes by cords. Cap mantles are mounted on supports, and the supports securely fastened to the caps.

as a considerable quantity of gas can be wasted in this way. Regulate the flow of gas through the burner with the burner key so that it burns with a steady, even flame, or use a burner that is self-regulating.

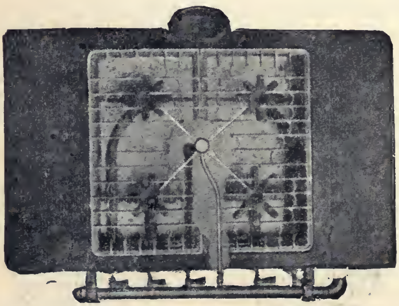


FIG. 130.—Why are the burners arranged in the shape of a star? Why are the burners in an oven arranged in a row?

It is quite necessary that all passages and orifices of gas burners be kept clean and in perfect condition to obtain the best results from the gas consumed.

Experiment with Burner.—Light a Bunsen burner. Allow as much air as possible to enter at the base. Note the results. Shut all the air off at the base and explain what happens. Adjust the burner so that a noiseless blue flame is produced. Experiment with a gas stove in the same way.

Types of the Bunsen Burner used on Gas Stoves.—There are two types of burners in general use on gas stoves. One is used for boiling and frying, and is so arranged as to produce a number of flames in a ring or star. The other type of burner is used for baking or broiling, and is so arranged as to have a number of little flames in a row.

Adjustment of Gas Burner.—The flame of a gas range should be so adjusted that the cross-sectional area of the outer cone is less than the cross-sectional area of the inner cone. The mixing disc near the stopcock should be so adjusted as to admit air enough to produce a blue inner cone. If too little air is allowed to enter, a yellow tip will appear on the cone; if too much, the burner will "flash back" or "burn back," and burn near the spud, or the inner cone will take on a greenish hue. This means that combustion is not complete. Acetylene, carbon monoxide (a very dangerous gas) and other poisonous gases will be given off, since the gas is only partly burned. The gas must be shut off and relighted, or the air mixer closed slightly, and then readjusted after the flame is lighted. The "flash back" is really an explosive action which carries the flame into the mixing tube and sets up combustion at the gas orifice.

Fig. 131.—Why are there holes in the disc? How could this burner be adjusted to get a blue flame?

Gas stove burners should be so adjusted that the blue-green central part of the flame is about half the height of the whole flame. If the flame is very long, and is bright yellow in part, too little air is being admitted; if short, and inclined to make a slight roaring noise, there is too much air. In the latter case the flame is liable to "strike back." In all gas burners the various openings should be kept clean.

Explosions are often caused while lighting the burners in a gas oven because large quantities of air mix with the gas which has entered the oven. The oven door should always be left open while the burners are being lighted.

The distance from the bottom of a dish on a gas stove to the

flame should be such that only the extreme tips of the outer cone touch the dish. The distance from the burner to the vessel should not be less than $1\frac{1}{4}$ inches, as the vessel in contact with the flame will chill it, checking combustion, and wasting gas by only partly burning it. A garlic-like or pungent odor gives warning of such conditions. Partly burned gas contains more or less of the poisonous gas carbon monoxide.

For proper combustion, all fuels must be supplied with many times their weight in air (oxygen). If enough air is not supplied, part of the fuel will not burn; if too much air is supplied, an unnecessary amount of heat is carried away in the smoke. The economy of different fuels depends upon how completely they burn. It is easy to see that coal is usually not entirely burned, since unburned pieces are found in the ashes. That gas, also, is not always entirely burned is not so well known because unburned gas is not visible.

On account of the danger of this gas (carbon monoxide) all gas water heaters, and gas and gasoline stoves, as well, should be supplied with flues to carry off dangerous or partly burned gases.

As carbon monoxide has no odor, it is extremely dangerous, for the gas may overcome a person before its presence can be detected. Recovery from such poisoning is less likely than from ordinary gas poisoning, for carbon monoxide unites with the blood, depriving it of oxygen, and seriously affecting the brain.

Questions

1. Why is it necessary to heat the burner of a gasoline stove before lighting the stove?

2. Why should one avoid cleaning cloth with gasoline in a room where there is a fire?

3. Why will a match go out without setting kerosene on fire if thrust down into the liquid quickly?

4. Why do kerosene lamps have wicks?

5. Why do candles have wicks?

6. Does the wax of the candle burn? Prove your answer with a match.

7. Why do some cities forbid the sale of gasoline in open cans after sundown?

8. How may you test the amount of gas consumed per hour by the different gas-consuming appliances?

9. Test some appliance at home.

10. Report on the condition of your gas meter as to a leak. How may you determine such a condition?

11. Why should gas burners be well adjusted?

12. Why do gas burners sometimes "burn back"? How may this be prevented? Why should one never allow a burner to "burn back"?

13. Find the gas pressure of your city in inches of water by attaching a U-shape tube half full of water to a gas fixture. The difference in the water level represents the gas pressure in inches. A column of water 1 foot high weighs 0.434 of a pound per square inch. Find the gas pressure in pounds in excess of the atmospheric pressure.

14. Why will a match go out if the match is held in such a position that the burning head will be above the wood?

15. Why must a fire be lighted at the bottom of the pile of wood?

16. Why does a flame burn just above a log in a fireplace?

17. Why may a candle be considered a gas generator?

18. Why does a candle or lamp smoke for a moment after being blown out?

OTHER FUELS

Water Gas.—Water gas is used in some cities as an illuminant. This gas is made by passing very hot steam over red-hot anthracite coal or coke. This gas burns with a colorless flame; therefore, it is necessary to mix some gas containing carbon with it in order to produce an illuminant. Oil is used for this purpose. As water gas is very poisonous, great care must be taken to prevent its escape into the room.

Natural Gas.—A cheap and convenient gas has been obtained from the earth. Natural gas is produced by the great heat within the earth acting upon the vegetable and animal matter at great depths. It is found in a highly compressed state in the pores of rocks. Wells are drilled into the earth, and the gas piped to the consumer.

Acetylene Gas.—This gas is produced by adding water to calcium carbide. It is especially rich in carbon, and gives a very white light. The gas is used for automobiles and stereopticons and, to some extent, for lighting houses. It is, however, very explosive when mixed with air, and because of its richness in carbon a special burner is required.

Prest-o-Lite.—Prest-o-lite is acetylene dissolved in acetone. A tank is filled with asbestos soaked in acetone. Acetylene is forced into the tank under pressure. The gas is dissolved in the acetone. When the gas is turned on for the lights, the pressure is reduced inside, and the acetylene passes from the solution.

Gasoline.—Gasoline is used for lighting and cooking. The tank of a gasoline stove is a little higher than the burner to which the gasoline runs. The heat changes the gasoline into a gas which burns as a blue flame.

Gasoline vapor is very explosive if mixed with air. Accidents have occurred through trying to fill the tank of a gasoline stove when the stove was lighted. The modern gasoline stove is so constructed that the tank cannot be filled while the stove is lighted.

Gasoline Engine.—The gas of gasoline is used in gasoline engines because of its explosiveness when mixed with large quantities of air. The gasoline is allowed to enter a *carburetor* where it is changed to a gas and mixed with air. From the carburetor the gas enters the cylinders of the engine, and is exploded by means of an electric spark.

All small and medium size gas engines operate on the four-stroke cycle principle. A four-stroke cycle engine completes one cycle of events in four strokes of the piston, i.e., the suction, compression, power and exhaust strokes.

First or Suction Stroke.

Gas and air, constituting the fuel charge, are sucked into the cylinder (*A*) through the inlet valve (*H*) as the piston (*B*) moves outwards, *away from* the cylinder head (*A*1). The exhaust valve (*H*1) is closed.

Second or Compression Stroke.

The piston (*B*) moving inward, *towards* the cylinder head (*A*1), compresses the fuel charge. Both inlet and exhaust valves (*H*) and (*H*1), respectively, are closed.

Third or Power Stroke.

Ignition by the spark ($J1$) of the compressed fuel charge produces explosion and expansion of the gases, forcing the piston outwards, *away from* the cylinder head ($A1$) during the power stroke. Both inlet and exhaust valves (H) and ($H1$), respectively, are closed.

Fourth or Exhaust Stroke.

The piston (B), moving inward, *towards* the cylinder head ($A1$), drives the burned gases out through exhaust valve ($H1$). Inlet valve (H) is closed.

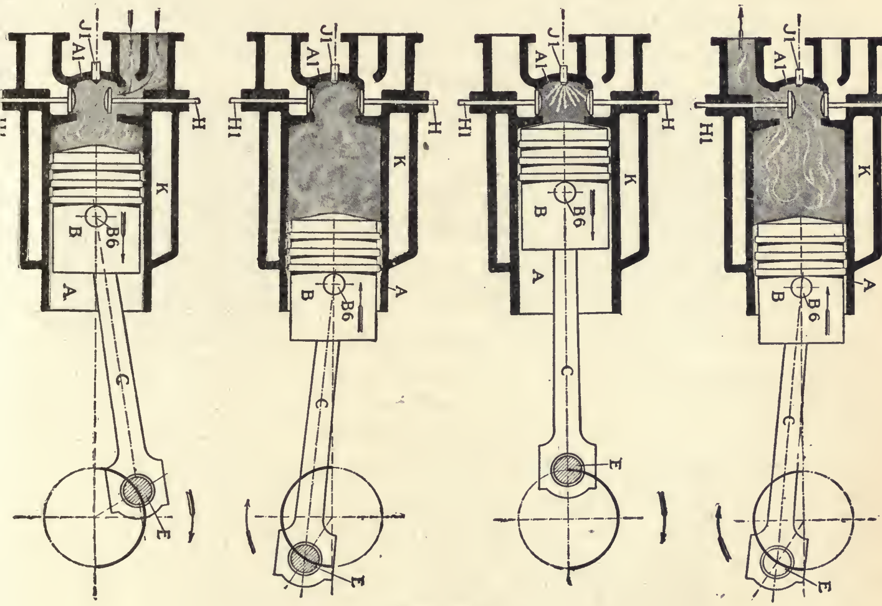


Fig. 132.

Thus the four strokes of the piston, i.e., one power stroke followed by three idle strokes, complete the cycle of events; hence we have a four-stroke cycle.

In a one-cylinder gas engine the flywheel thus makes two revolutions for every power stroke. In a two-cylinder engine, with alternate explosions in the two cylinders, one power stroke occurs for every revolution of the flywheel.

Cooling.—In small and medium-size gas engines a temperature of from 2000° F. to 2600° F. is developed at the instant of explosion of the gases in the cylinder. As the gases expand the temperature decreases. The average temperature of the expanding gases is about 1400° F. during the power stroke.

Cóoling of all parts of the engine that come in contact with the hot gases is necessary. Without adequate cooling, unequal expansion and distortion of the overheated parts, excessive wear and piston seizure would occur.

The *cylinders* of both small and medium-size horizontal gas engines are nearly always water-cooled.

Alcohol as a Fuel.—It is far more economical to use denatured alcohol, which is largely grain alcohol, as a fuel than ordinary wood alcohol, since one part of grain alcohol will give the same amount of heat as two parts of wood alcohol.

Coal.—Coal beds were once great swamps in which trees and plants have fallen and turned into coal. Some of the trees were very different from those of to-day. Fossil trees found in the coal mines tell us the trees must have been in some cases 50 feet high and 4 feet in diameter.

Coal is divided into two general classes:

1. **Anthracite** coal, or hard coal, which ignites with some difficulty, but burns slowly with intense heat.

2. **Bituminous** coal, or soft coal, which ignites readily and burns easily, if there is a good draft. Soft coal should be put on the fire in small quantities, as the gases escaping from the coal may not all burn, causing a great deal of smoke and wasting valuable heat.

Two gases form during the burning of coal, carbon dioxide and carbon monoxide. The carbon monoxide is formed in the lower part of the fire, rises to the top and is seen burning with a blue flame at the top of the coal fire. If there is not sufficient air at the top of the fire, some of this gas escapes up the chimney or into the room, unless the drafts are properly adjusted. People have often been killed by this gas escaping into a sleeping room during the night.

Cannel coal is very rich in volatile matter. It is very compact in texture, and has an oily appearance. Kentucky, Indiana, and Ohio furnish a small supply of this coal.

Peat.—In Ireland and in the United States there are great bogs in which trees and plants are decaying every year, forming a thick black mud called **peat.** In wet places the peat forms very rapidly.

Roman coins left by the soldiers 2000 years ago have been found covered by 10 feet of peat.

For use as a fuel peat is often dried and pressed into blocks.

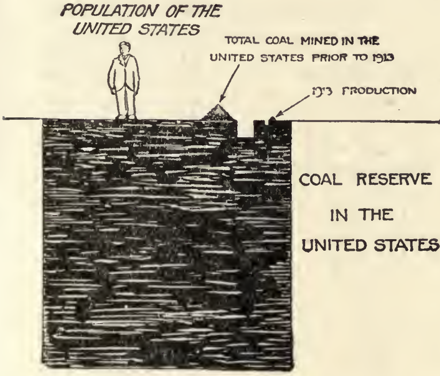


Fig. 133*B*.

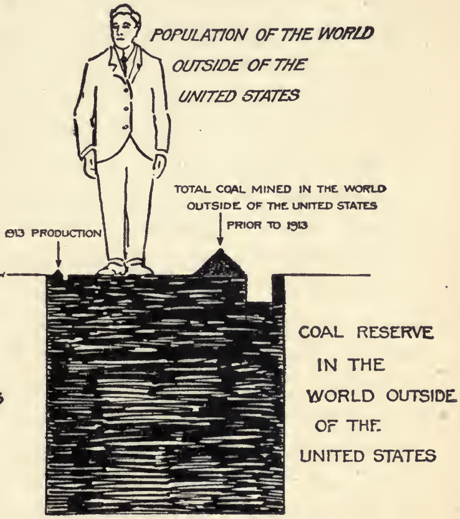


Fig. 133*A*.
Courtesy of National Geographic Magazine

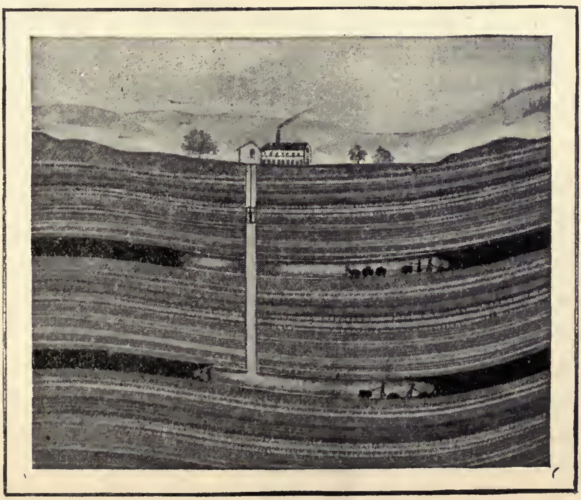


Fig. 133*C*.—Mining Coal.

Heating Values of Fuels.*—The heat required for heating, cooking, and other purposes may come from any one of several sources, and the one chosen should depend upon the cost and convenience of the heat supplied by these different sources. The table below gives the approximate amount of heat produced by burning several different kinds of fuel, as determined by the Bureau of Standards; also the number of gallons of water which could be heated from 32° to 212° F. (0° to 100° C.) for one cent, if no heat were lost.

These figures apply to the cost of the heat actually supplied to the water, but the true cost of any operation, like heating a kettle of water or baking a loaf of bread, will depend also upon what proportion of the heat is utilized, and this again will depend upon the nature of the fuel. For instance, a coal fire must be kept burning for a long time in a stove of considerable size because much of the heat from the fuel is used in heating the stove, and still more is radiated from the heated surface of the stove, while perhaps only a very little heat is actually used in cooking. A gas burner, on the other hand, may be lighted and turned out quickly, and because there is no large amount of metal to heat, much less heat is wasted. For this reason gas, which costs six times as much as hard coal for each heat unit, may still be cheaper to use than coal when heat is needed for only a short time.

Heating of Rooms.—The proper heating of a residence is a matter of the utmost importance, as upon it depend the comfort and health of the occupants. Two essentials are a supply of heat and a supply of fresh air. The supply of heat is usually given some attention, while the supply of air is often sadly neglected.

When fuel is burned in a furnace, stove, or grate for heating purposes, part of the fuel is usually left unburned, part of the heat produced passes off up the chimney, and part may be lost from hot water, steam, or air pipes running to the several rooms. The remainder is utilized in heating the air in the room, and in supplying the loss of heat through the walls, doors, and windows.

The Amount of Heat Required to Warm Fresh Air.—A certain amount of heat is, of course, required to keep a house warm in cold weather, even if no fresh air is admitted; and if cold fresh air is

* From the Bureau of Standards.

admitted, heat is necessary also to warm this air, but the amount of heat needed for this purpose is not large. If the air outside is at a temperature of 32° F. (freezing point), and is to be warmed to 70° F., it would require about 2 pounds of coal per day to heat an ample supply of air for one person (2000 cubic feet per hour). Thus in heating residences an ample amount of fresh air can be allowed without greatly increasing the cost of heating.

COMPARISON OF FUELS.

Material.	Heating Value.	Price.	Gallons of Water which could be Heated from 32° to 212° F. for One Cent.
	Btu. per lb.		
Softwood..........	8,000	\$4 per cord (2 tons)	53.0
Hardwood.........	8,000	\$4 per cord (3 tons)	80.0
Soft coal..........	13,000	\$4 per ton	43.0
Hard coal.........	13,000	\$7 per ton	25.0
Coke..............	12,000	\$5 per ton	32.0
Charcoal..........	16,000	\$25 per ton	8.5
Fuel oil...........	18,000	\$1.25 per barrel (50 gal.)	36.0
Kerosene..........	18,000	\$0.10 per gallon	8.3
Alcohol...........	12,000	\$0.50 per gallon	1.0
Gasoline..........	19,000	\$0.20 per gallon	3.5
	Btu. per cu.ft.		
Natural gas........	1,000	\$0.40 per 1000 cubic feet	17.0
Manufactured gas	600	\$1.00 per 1000 cubic feet	4.2
	Btu. per kw.hr.		
Electricity.........	3,400	\$0.10 per kilowatt hour	0.23
	Btu. per lb.		
Ice (to absorb heat)	160	\$0.35 per hundredweight	*0.32

* Melting ice absorbs 143 Btu. per pound, but ice water thus formed also absorbs from 15 to 20 Btu. additional before it leaves a refrigerator, making a total of about 160 Btu.

Amount of Heat Used in Cooking.—In solving household problems it is important to know how much heat is used. It takes about 180 Btu. to heat a pound of water from freezing to boiling temperature, and it takes nearly 970 Btu. to boil away that amount of water. " A watched pot never boils " is a saying containing much

truth, since **removing the cover** of a vessel in which water is being heated allows much heat to escape. Long before water begins to boil steam is leaving the surface of the water, and each 5 drops of water thus taken away as steam absorb enough heat to heat about a pound of water 1°. If a tight cover is kept in place the escaping steam will mostly condense on the cover, and much of the heat which it contains will be kept within.

When water is kept boiling for cooking foods the object is to keep the food hot enough for cooking; that is, at the temperature of boiling water. But the water also prevents the food from getting too hot, because no matter how fast water boils it gets no hotter, and the cooking will proceed no faster. Whatever heat is used up in boiling away more water than necessary is entirely wasted, not to mention the disastrous effect of allowing all the water to boil entirely away. Therefore, after boiling has begun, a gas or oil flame can be turned down considerably without delaying the cooking, provided the water keeps boiling.

To Save Heat, Keep the Cover On.—But there are other processes where the boiling away of the water is the main object, as in the boiling down of sirups, the making of candies or jellies, etc. Here, instead of saving heat by boiling slowly, heat may be saved by boiling briskly, since by so doing it will take less time, therefore less gas or coal, to boil away the required amount of water. Here no cover should be used, since a cover would prevent the escape of some of the steam.

In baking operations there is not much chance for the saving of heat except in the selection of an oven. Baking in the ordinary oven is a very wasteful process indeed, for more than 90 per cent of the heat supplied is usually lost through the sides of the oven. Such loss of heat could be made much less if the walls of all ovens were made with a thick layer of heat-insulating material. Electric ovens are usually well insulated, since without some means of saving heat the cost of baking by electricity would be altogether prohibitive because of the relatively high cost of heat supplied in this way.

Regulation of Stoves, Ranges, and Other Heating Appliances.—The air which enters cold below the fire in any stove or furnace

passes up through the fire, producing combustion and absorbing the heat produced, except that which escapes through the side of the firebox. This heated air may then be utilized for heating in one of several ways, as by letting it pass around water tubes or through flues in a boiler, around air flues in hot air furnaces, around the oven in a cooking range, or through a heating drum and length of pipe in the common heating stove. Whatever heat is left in the gas when it enters the chimney is useless except for increasing the draft. It is therefore important to utilize as large a proportion of heat as possible before the gases reach the chimney. This can be done by (1) having the gases as hot as possible, (2) allowing them to pass out as slowly as practicable, and (3) bringing them into the best possible contact with the flues, oven sides, or other heating surfaces.

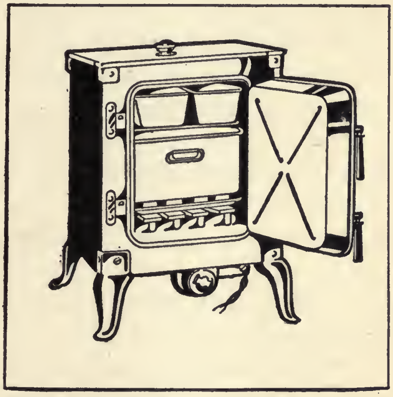


FIG. 134.—Electric oven. Why is it necessary to have heavy non-conducting walls on this oven?

Good contact between the flue gases and the heating flues can be obtained in any given stove or furnace only by keeping the flues clean and free from soot and ashes. This is very much more important than most persons realize.

The gases will be hotter and will also pass more slowly the less their amount; therefore, no more air should be admitted to the stove or furnace than is necessary. This applies particularly to air which might be admitted over the fire by opening the fire door or a draft in it, except under the following conditions:

When combustion gases are produced by the heating of fuels such as soft coal, or wood, it is sometimes necessary to admit air over the fire so as to permit the gases to burn. Therefore, with such fuels some air should be admitted through the fire door, or in some other manner immediately over the fire, so long as a bright flame is produced.

With hard coal, coke, and charcoal, as well as with wood or soft coal, after the flame has burned out no air should be admitted over the fire.

In most cooking ranges, and in some heating stoves and furnaces, there is a damper which permits smoke from the firebox to pass directly to the chimney without passing through the heating flues. One should learn how such a damper operates and keep it closed, except possibly when first starting up the fire. Opening this damper will often make the fire burn more briskly, but most of the extra heat thus produced is usually lost up the chimney. In summer, however, when extra heat is not desired, this damper may be left open to allow heat to escape up the chimney.

Questions

1. Why is water gas more dangerous to use than coal gas or "city gas"?
2. How many tons of coal are required to heat your home?
3. How many Btu. are given off?
4. What is the cost per million Btu.?
5. How many cubic feet of gas would be required to obtain the same number of Btu.?
6. What would be the difference in cost in heating your home with gas as compared with coal?
7. Find the price of wood in your town, and compute the cost of heating your home with wood?

Note. In all cases of fuels, use the selling price as you find it in your locality.

8. Why should great care be taken to regulate the drafts of a coal fire?
9. Why does a blue flame appear over a coal fire when the stove door is opened?
10. How may heat be saved during cooking processes?
11. Why should the gas be turned down low after water is boiling?
12. Why is heat lost if water boils violently and steam escapes around the cover?

VENTILATION

Results of Burning.—Most gases contain carbon, carbon monoxide, and a gas called hydrogen. We have learned that oxygen unites with substances to form oxides during the process of combustion. Carbon unites with oxygen to form carbon dioxide. Carbon monoxide unites with oxygen to form carbon dioxide. Hydrogen unites with oxygen to form **hydrogen oxide** (water) (H_2O).

Symbols or formulas are used to express these compounds. C stands for carbon, O for oxygen, and because two parts of oxygen unite with one part of carbon the formula for carbon dioxide is CO_2. Carbon monoxide would be expressed by CO. More oxygen can unite with this compound; therefore, it can burn. When oxygen can no longer unite with the compound, that is, when it has all the oxygen it can hold, it can no longer oxidize, and hence can no longer burn. The same is true of hydrogen, a gas we shall study about in the chapter upon water.

Carbon Dioxide (CO_2).—Carbon dioxide will be seen to be the chief product of combustion. We have already learned that this gas is useful in extinguishing fire. It is also used for **soda water.** Large quantities of the gas are forced into pure water in tanks. These tanks are attached to the soda water fountain, and the carbonated water is drawn off into glasses, flavored with chocolate, vanilla, etc., and sold to the customers. Water containing large amounts of carbon dioxide is called **carbonic acid.**

Sources of Carbon Dioxide (CO_2).—Every chimney is giving out large quantities of CO_2 to the atmosphere. It was estimated at one time that certain iron works sent into the atmosphere every day more than five million pounds of carbon in the form of carbon dioxide. The burning of gas, the burning of wood, and the exhaling of air by human beings and animals give to the air large quantities of carbon dioxide.

A single adult will give off nearly 2 pounds of carbon dioxide every day, or about 22 cubic feet. That is, the normal person breathes out about .9 cubic foot each hour.

The amount of air in the average person's lungs is from 210 to

215 cubic inches. The **tidal air,** or the air we inhale and exhale, amounts to about 20 to 30 cubic inches.

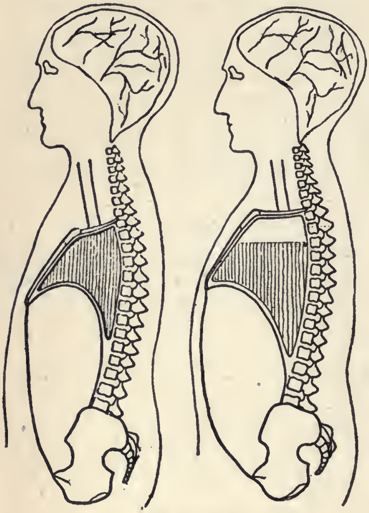


Fig. 135.

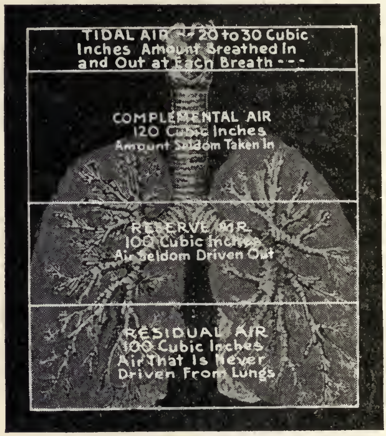


Fig. 136.

Amount of Air Breathed.—An adult uses about 30 cubic inches of air at each breath. The average person breathes about twenty times per minute.

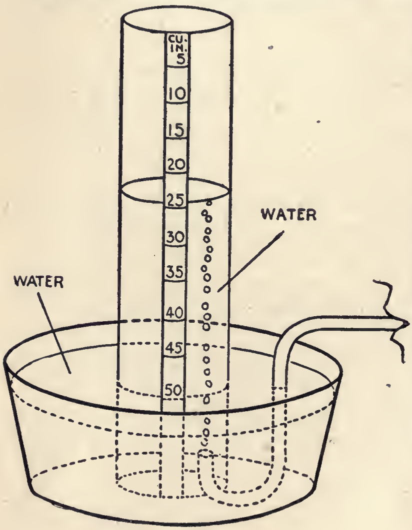


Fig. 137.

Fill a large bottle or cylindrical jar with water and invert it in a large pan of water. Place a rubber tube under the mouth of the jar, as shown in Fig. 137. Take the deepest breath possible. Place one end of the tube in the mouth and force as much air as possible out of the lungs into the bottle. Determine from this the number of cubic inches of air forced into the bottle. Such an instrument may be called a **spirometer,** an instrument for measuring lung capacity.

By placing a strip of paper on the side of the bottle, a scale may be drawn so as to show the number of cubic

inches of water forced out of the bottle. Covering the paper with shellac will fasten the scale firmly to the bottle.

A gallon contains 231 cubic inches.

A cubic centimeter contains .061 cubic inch.

Need of Ventilation.—All authorities agree on the necessity of ventilation, but not all agree as to the reason why air must be constantly changed. Some have believed that carbon dioxide made the air impure. This is not generally accepted to-day. Others feel that the air becomes heated by the presence of people in a limited or confined space. They are forced to take shorter breaths, and the general activity of the body decreases.

Another reason given for ventilation is that noxious gases called anthrotoxins are given off which, if breathed in large quantities, have poisonous effects on people.

All agree, however, that large quantities of fresh air are necessary to produce the right kind of activity for mind and body.

To prevent the air from becoming impure, each person requires about 2000 cubic feet of fresh air each hour.

Children at different ages require different amounts of air. In the primary grades each child should get about 2000 cubic feet of air per hour, and in the grammar grades from 2500 to 3000 cubic feet of air. The children do not breathe all the air, but each child vitiates this amount and renders it unfit to breathe.

It is possible, as far as the amount of oxygen in exhaled air is concerned, that air be reinhaled, since the lungs contain a large percentage of CO_2, and pupils could get along on a smaller amount of air. But the rule should be definitely fixed in mind that fresh air is " Nature's Greatest Remedy " for keeping us well, and the nearer the percentage of CO_2 in the air of the room approaches to that out-of-doors, the nearer we are living as nature intended.

Different Amounts of Oxygen in the Air.—It is necessary to ventilate a room because the inhaling of air which has already been exhaled exerts an unhealthy influence on the human organism. Normal air contains about 21 per cent oxygen. A candle is extinguished in air containing less than 17 per cent but the percentage can be reduced to about 14 per cent without any apparent effect on the body. If the proportion is reduced to 12

per cent, the breathing becomes altered. At 10 per cent the color of the face of a person breathing it becomes of a leaden hue, the heart palpitates, bodily and mental activity become difficult. At 6 per cent consciousness is lost; and death takes place when the percentage of oxygen in the air is reduced to 3 or 4 per cent.

	Per Cent of Oxygen.	Per Cent of Nitrogen and Rare Gases.	Per Cent of Carbon Dioxide.
Pure air....................	21	79	0.03
Expired air.................	16	79.6	4.39

The air that leaves the lungs contains more than 100 times as much carbon dioxide as the air that enters.

Laws Regarding Ventilation.—The ideal room should have about 600 cubic feet of air space for each person. Some States require that each class room shall have 30 cubic feet of air per minute for each pupil by an approved ventilation system, that each pupil shall have 18 square feet of floor space and at least 200 cubic feet of air space, and that all classroom ceilings shall not be less than 12 feet from the floor. What does the law require in your State? Teachers and students should demand that these conditions be met to safeguard their health. See that the law is lived up to. This is one way of being a good citizen.

Method of Ventilation.—Air should never be allowed to become stagnant. One of the best methods of ventilating a room is to flush it out several times each day by opening the windows. This should be done when the students are out of the room. This method would be unwise if people were present, as the air is cooled, and a cold draft and sudden cooling of the body might produce serious results.

Although the windows of the room should be opened during the day, this does not mean the room should be closed at other times so that no more fresh air is admitted. There should be a steady supply of fresh air, heated to the proper temperature, and having the correct amount of humidity.

A window board about 6 inches wide is another means of supplying fresh air. The board is arranged so as fit the side of the

window and the window-sill, and allow the air to enter from the open window behind the board. Fresh air will enter and be deflected upward toward the ceiling; it then gradually sinks and spreads throughout the room.

A piece of cloth stretched on a frame and fitted into the open window makes another type of ventilator which is quite practical and inexpensive.

A wood or grate fire is an excellent ventilator. A heating system which introduces warmed new air is far better than a heating system which depends on direct radiation.

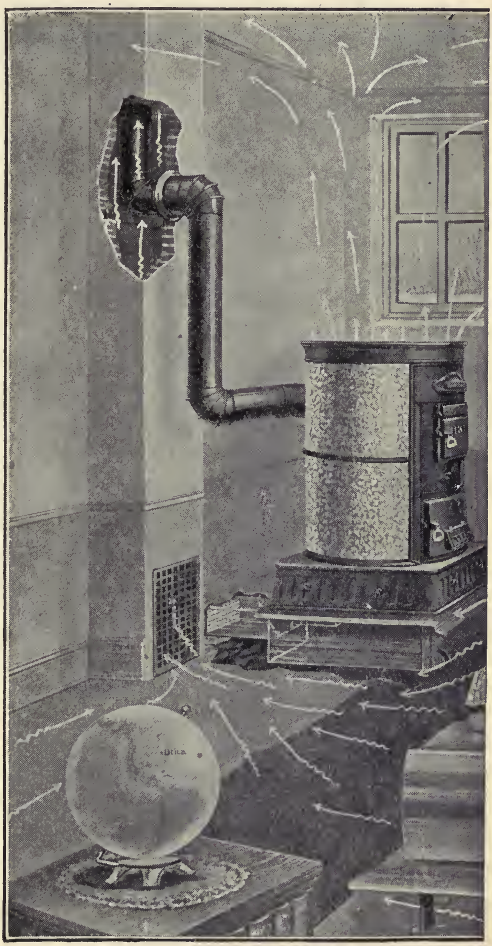


FIG. 138.—Air circulating about a jacketed stove. Fresh air is taken from out doors.

Difficulty of Ventilation by Windows.—We have learned that fresh air from outside will rush into the room if the air inside is lighter than the air outside. This is usually the case during the winter months. It does happen in some climates that the outside temperature is the same or nearly the same as the inside temperature. Windows may be opened in the morning, producing a satisfactory amount of ventilation, but as the day gets warmer it is

necessary to readjust the windows. No one could adjust the windows in the morning and expect sufficient fresh air to enter later in the day. The greater the difference in pressure between the outside and the inside of a building the less the windows need to be opened.

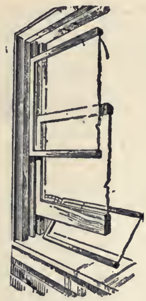


FIG. 139. Board arranged in window.

Passage of Air through the Substance of Walls.—A small amount of air passes through the materials from which walls are made. More air passes through when the difference in pressure is great between the outside and inside of the house. From 30 to 80 cubic feet of air per square foot per hour will pass through ordinary flooring for a difference in pressure of 1 pound per square foot. The amount of air which will pass through an ordinary brick wall for the same pressure and time will be about 48 cubic feet.

Carbon Dioxide not Injurious.—It has been definitely proved that carbon dioxide in the air is not injurious. People have worked for many years in mineral water factories or in breweries, breathing air which contains a relatively large proportion of carbon dioxide, without suffering any ill effects. Carbon dioxide breathed within certain very wide limits, up to 300 parts in 10,000 parts of air, appears to make very little difference. The reason for this is that the presence of carbon dioxide in the blood excites the breathing centers, and automatically causes the breathing to be deeper and stronger, resulting in the quantity of carbon dioxide in the blood remaining constant.

Effects of Carbon Dioxide on the Body.—Although carbon dioxide is not considered dangerous in the air, carbon dioxide exhaled from the lungs with other substances seems to produce some ill effects on the body, according to some investigators. Certain amounts cause drowsiness and mental dullness. Long exposure to such an atmosphere causes paleness. This is because of decrease in the amount of oxygen necessary to maintain life, and the vitiating of the atmosphere.

The "Choke Damp" found in mines is carbon dioxide. Often large quantities collect in wells. Before cleaning a well, lanterns are usually lowered into the well to test for its presence.

The headaches and disagreeable feelings produced by breathing air in crowded rooms are due to the overheating, to the moisture of the air, and to the disagreeable odors, and not to the carbon dioxide.

Tests to Determine Conditions of the Air.—Air can best be tested for its fitness to breathe by the sense of smell. However, the sense of smell is fatigued very rapidly, and it is necessary for one to come from fresh air in order to make a reliable test. Thus the teacher and pupils, or members of the household, would be unable to tell when the air was impure and unfit to breathe. Anyone coming from out-of-doors would detect odors and unhealthful conditions of the atmosphere.

Why We Measure the Carbon Dioxide in the Room.—The carbon dioxide is measured in a room to determine the amount of carbon dioxide which has been exhaled by people. It is not because the carbon dioxide is poisonous, but because organic matter is exhaled from the lungs and the skin of people at the same time the carbon dioxide is exhaled. By measuring the percentage of carbon dioxide in the atmosphere it is easy to determine indirectly the relative amount of contaminated or vitiated air, providing the carbon dioxide was produced by respiration.

Test for Amount of Carbon Dioxide (Dewing).—One of the simplest tests for CO_2 is to make up a test solution of

2 or 3 drops of phenolphthalein solution;
1 c.c. of a saturated solution of lime water;
Sufficient water to make 100 c.c. of the solution.

The water should have the phenolphthalein added and a few drops of lime water (enough to produce slight discoloration before the cubic centimeter of lime is added).

Place 10 c.c. of the solution in a large test tube. Obtain a large size dowel pin 12 inches long, graduate the stick by placing it in a graduate half full of water, and notice how far the stick must be inserted to displace 10 c.c. of water. Divide the stick from this point into 10 equal parts, each part representing a cubic centimeter. Insert the stick into the test tube to the 10 c.c. point, which will force out 10 c.c. of air, or 20 c.c. of air if the test tube is long enough and the stick has been graduated to show 20 c.c.

As the graduated stick is removed, the air of the room enters the test tube. Shake the air thoroughly into the test liquid. Repeat, removing the air and allowing new air to enter by means of the graduated stick. Shake the test tube each time until the test solution has lost its color, or has returned to the

faint pink color it possessed before the last cubic centimeter of lime water was added.

The number of cubic centimeters of air required to discolor the liquid gives us the percentage of CO_2 in the atmosphere.

Air Required to Produce Discoloration. Cu.cm.	Per Cent of Carbon Dioxide in the Air.	Air Required to Produce Discoloration. Cu.cm.	Per Cent of Carbon Dioxide in the Air.
30	.28	91	.09
36	.22	103	.08
46	.18	118	.07
58	.14	138	.06 Fair
69	.12	165	.05
82	.10 Bad	207	.04 Good

Air showing 10 parts or more of carbon dioxide is badly vitiated.

Carbon dioxide forms a white precipitate in lime water; hence this is used as a test for the presence of the gas.

Fill a test tube half full of saturated lime water, and blow gently through a piece of glass tubing into the water. What does this show regarding the atmosphere we breathe out? Test the city gas for the presence of carbon dioxide.

Allow a candle to burn in a bottle until it goes out. Test for the presence of CO_2 by pouring in a few teaspoonfuls of lime water and shaking the bottle vigorously for a moment.

Complete apparatus using the above method is sold by L. E. Knott, Boston, Mass.
The Standard Scientific Co. of New York City manufactures a very simple apparatus for testing for CO_2.

Experiment to Show the Best Method of Ventilation.—If you observe the duct for incoming air and the one for outgoing air you will see that they are on the same side of the room, one at the top and one at the bottom.

Build a little box to represent a room, as shown in diagram 141. Place a piece of glass in front of the box, and bore four holes on each side to represent the ducts for incoming air and outgoing air, or the windows of a room.

1. Light the candles, after stopping the holes with a cork stopper. The candles will soon go out. Why?

2. Relight the candles and remove one stopper from each side at the top, *A* and *C*. The candles will burn for a short time, and then go out. Why?

3. Remove the two stoppers at the bottom *B* and *D*, with the other holes closed. The candles will go out after a short time. Why?

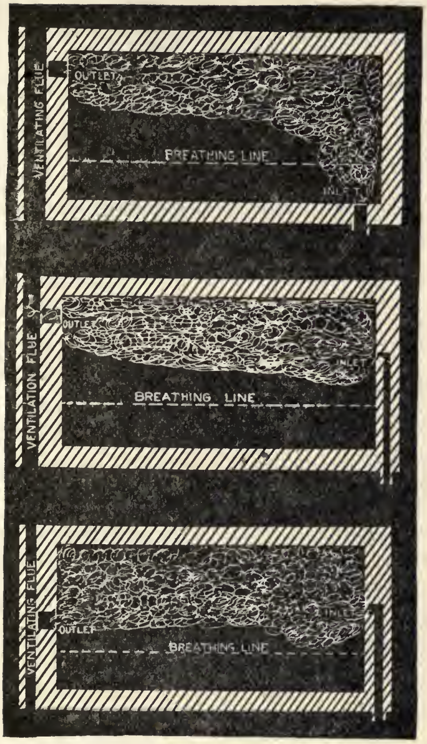


Fig. 140*a*.

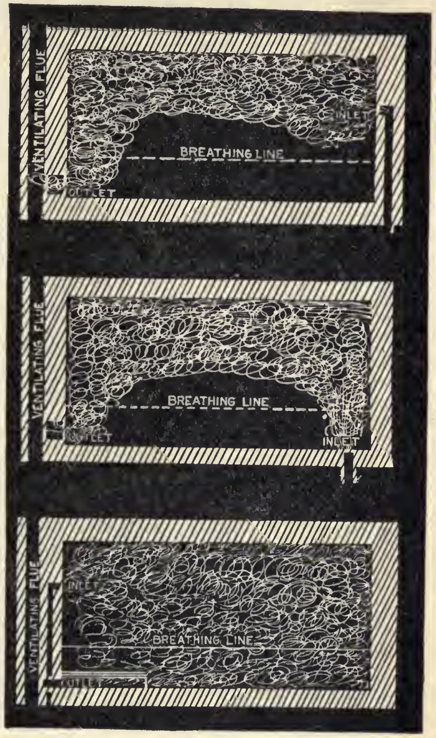


Fig. 140*b*.

What is the effect on the ventilation of a room, 1. If the air enters at the floor and passes out on the opposite side at the top? 2. If the air enters on one side of the room near the top and passes out on the opposite side near the top? 3. If the air enters about half way from the ceiling on one side and leaves the room on the opposite side at about the same distance from the top? 4. If the air enters from the side wall a few feet from the ceiling and leaves on the opposite side at the bottom? 5. If the air enters from the floor on one side of the room and passes out on the opposite side of the room near the floor? 6. If the air enters and leaves on the same side of the room? 7. For good ventilation, what is the best way for air to enter and leave a room?

4. Remove one stopper at *A* on one side and at *D* on the other side. Watch the candles. Tell which candle is getting a better supply of air.

5. Open one hole at *A* and one at *B*, on the same side of the box. The candles will burn until used up, which shows that the best ventilation is obtained by having the openings at the top and bottom on the same side of the room.

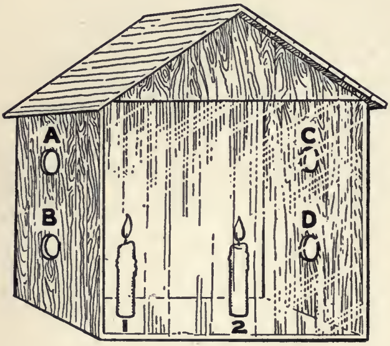


Fig. 141.

Disease and Fresh Air.—Fresh air cures many diseases, especially consumption. If fresh air will cure disease, it will **prevent disease.**

When our ancestors lived in the open air, disease and ill health were not as common as now-a-days with our crowded homes, overheated houses, and poorly ventilated school rooms. The open air school is a step toward good health and prevention of disease. Sleeping with our windows wide open, giving us plenty of fresh air, helps to make us healthy. Live and sleep out of doors as much as possible. Those who spend their lives in the open enjoy longevity and the best of health. Even damp foggy air out-of-doors is far more healthy than air in the house.

Deep Breathing.—" One hundred deep breaths a day" is an old recipe for avoiding tuberculosis. Ventilate the lungs every day by pressing the finger on the side of the nose so as to close one nostril, breathing in through the other nostril, and then out of the first. Reverse the process for every other breath. Singing causes deep breathing, and is a good way of getting fresh air into the lungs.

Air Vitiated by Lights.—Years ago candles were about the only means of illumination. The replacing of candles by gas and electricity made lighting more convenient, as well as more hygienic. In rooms where candles were used, the air was vitiated very rapidly. Every candle vitiates as much air as twelve people. A Welsbach gas light uses up as much oxygen as three people. This means that a person in a room with one gas light must provide as much air as

would be needed for four people. Electric lights, of course, do not vitiate the air at all.

A candle will remove from the air in one hour about 10 cubic feet of oxygen, while an adult will remove about one-quarter of a cubic foot. A candle will produce about 7 cubic feet of carbon dioxide, but a human being will produce less than a cubic foot of carbon dioxide per hour.

The following table is of interest because it shows the relation between the air vitiated by different lights and by an adult person.

	Quantity Consumed per Hour.	Candle-power.	Oxygen Removed per Cubic Foot.	CO_2 Produced, Cubic Foot.	Moisture Produced, Cubic Foot.	Heat Produced, Calories.	Vitiation Equal to Adult Persons.
Tallow candles	2200 grains	16	10.7	7.3	8.2	1400	12.0
Sperm candles	1740 "	16	9.6	6.5	6.5	1137	11.0
Paraffin oil	992 "	16	6.2	4.5	3.5	1030	7.5
Kerosene oil	909 "	16	5.9	4.1	3.3	1030	7.0
Coal gas (fishtail burner)	5.5 cu.ft.	16	6.5	2.8	7.3	1194	5.0
Coal gas (argand lamp)	4.8 "	16	5.8	2.6	6.4	1240	4.3
Coal gas (regenerative)	3.2 "	32	3.6	1.7	4.2	760	2.8
Coal gas (Welsbach burner)	3.5 "	60	4.1	1.8	4.7	763	3.0
Electric lights (Filament)	Any no. of watts	all	0	0	0	0	0

The Relation of the Use of Gas to Vitiated Air.—From the table it might be thought that the use of gas as an illuminant would be very unhygienic and would remove a great deal of oxygen from the atmosphere. Of course gas flames do not remove as much oxygen as candles. The gas flame produces carbon dioxide and a small amount of sulphur dioxide, but gas burning in a room causes the air to circulate very rapidly. It also burns up some organic impurities, since the temperature of the gas mantle is about 1500° Fahrenheit when incandescent. To cause circulation of air, the gas burner is often used in vents in order to drive obnoxious odors up the flue.

Questions

1. What is foul air?

2. How does it affect life?

3. Why should people sleep with their windows open?

4. What do miners call carbon dioxide?

5. What are the effects of breathing small quantities and large quantities of carbon dioxide?

6. What are some of the fallacies regarding ventilation?

7. What system of ventilation has your school?

8. What is necessary for satisfactory ventilation of public buildings?

9. How may drafts be avoided in ventilating a room?

10. Why does sleeping out-of-doors benefit a person?

11. Why do some people consider night air unhealthy?

12. What kinds of lights do you use in your home? How many people would be required to vitiate the same amount of air?

13. How is one able to tell when the air in a room is bad?

14. What is the best way of airing out a room?

15. In what position must the "inlet" and "outlet" of a ventilating system be placed to get the proper kind of ventilation?

16. Draw a diagram of the ventilating system of your school. (Special report.)

17. Why does a white, crusty skin form on the top of a jar of lime water left open in a room?

18. Test your lungs with the exhaling bottle for the amount of air you breathe out. Described on page 172.

19. Count the number of times you breathe each minute.

20. How many cubic feet of air do you exhale in one hour?

21. Expired air contains about 4 per cent, and fresh air about 0.03 per cent, of CO_2. Find the amount of CO_2 in the air exhaled. Divide the amount of carbon dioxide in tenths of cubic feet exhaled in one hour by 0.0003. Why will this give you the number of cubic feet of air required per hour?

22. Find the size of your school room.

23. How many cubic feet of air space are allowed for each pupil?

24. How many cubic feet of air space are allowed in your living room for each person (count in the lights)? In your sleeping room?

25. How often must the air be changed in your school room? In your living room? In your sleeping room?

26. Draw a diagram of the ventilating system in your home.

CARBON CYCLE

Digestion.—Foods contain: carbon and hydrogen in the form of **carbohydrates** (sugars and starches); **fats**, (butter, oils, fats of meat); **proteids** (white of eggs, lean meat, gluten of wheat), which are carried to the stomach and digested. Digestion is the process of changing a food from a material which **cannot be dissolved** to a food which **can be dissolved** (from non-soluble to soluble.)

Most of our foods do not dissolve in water, or in the juices of the alimentary canal. The food we eat, such as butter, eggs, meat, bread, etc., must be changed to a substance which will dissolve and pass through the walls of the stomach and intestines into the blood.

The principal fuel and source of energy in the body is sugar. No one eats anything like the required amount of sugar in his food, because we eat about three pounds of food a day, and since sugar furnishes two-thirds of our entire working and warming powers, it would mean that each person would have to eat from a pound and a half to two pounds of sugar if the required amount were eaten **as sugar.**

All the starch which we eat must be changed into sugar, since starch will not dissolve and pass into the blood. Our bread, crackers, cakes, cereals, potatoes, rice, corn, wheat, etc., contain large amounts of starch which must be changed into sugar by a simple process known as **hydration.** This is Nature's method of adding water to the starch, thus changing it into sugar. This process of digestion begins in the mouth. In the saliva there is a substance called ptyalin (tī-a-lin) which attacks the starch, and begins to change it into malt sugar. The food then passes to the stomach and is changed from malt sugar to grape sugar, so called because it was first found in grapes, or **glucose.** This process of digestion continues from the mouth all the way down the alimentary canal through the small intestines.

The grape sugar or glucose dissolves readily, and passes into the blood, where the hydrogen and the carbon oxidize, producing large quantities of heat and energy. This process of oxidation is sometimes called **wet burning.**

How the Body Supplies Oxygen for the Burning of Food.—The blood gets its oxygen from the atmosphere through the process of **respiration.** The lungs are composed of a great mass of air passages and air sacs (about 725,000,000). Because of the great number of blood vessels in the lungs, as much blood goes to the lungs as goes to the remainder of the body at any one time. The walls of the air sacs are very thin. The oxygen passes through the walls of the sacs and enters the blood. In the blood little red corpuscles containing a substance called **hemoglobin** act as the carriers of the oxygen. The hemoglobin unites with the oxygen, or, in other words, takes a load of oxygen away from the lungs and delivers it to the cells of the body. When the stomach is filled with a hearty meal a great many red corpuscles go to the vicinity of the stomach and intestines where the food is entering the blood. The oxygen oxidizes the food, making it give off large quantities of heat and energy.

A part of the proteid food is used to build up the cells of the body; the rest is oxidized or burned up, forming carbon dioxide, water, and uric acid. The carbohydrates and fats, when oxidized, form carbon dioxide and water. All of our foods, upon burning, give us large quantities of heat and energy which are required to maintain the body temperature and give us strength to do our work.

Animals that Store away Food.—Some animals hibernate all winter by storing fat in the body and using it up during the winter sleep. Camels store fat in the humps on their backs that they may be able to travel for days in the desert without food.

The Removal of Carbon Dioxide from the Body.—All the carbon dioxide produced by the burning of food in the body must be removed. The carbon dioxide is dissolved by the **plasma,** the chief element of the blood, composed mainly of water. The function of the plasma is to carry waste. The hemoglobin of the red corpuscles also assists the blood plasma in disposing of the carbon dioxide. Its chief function, however, is to carry oxygen when the blood

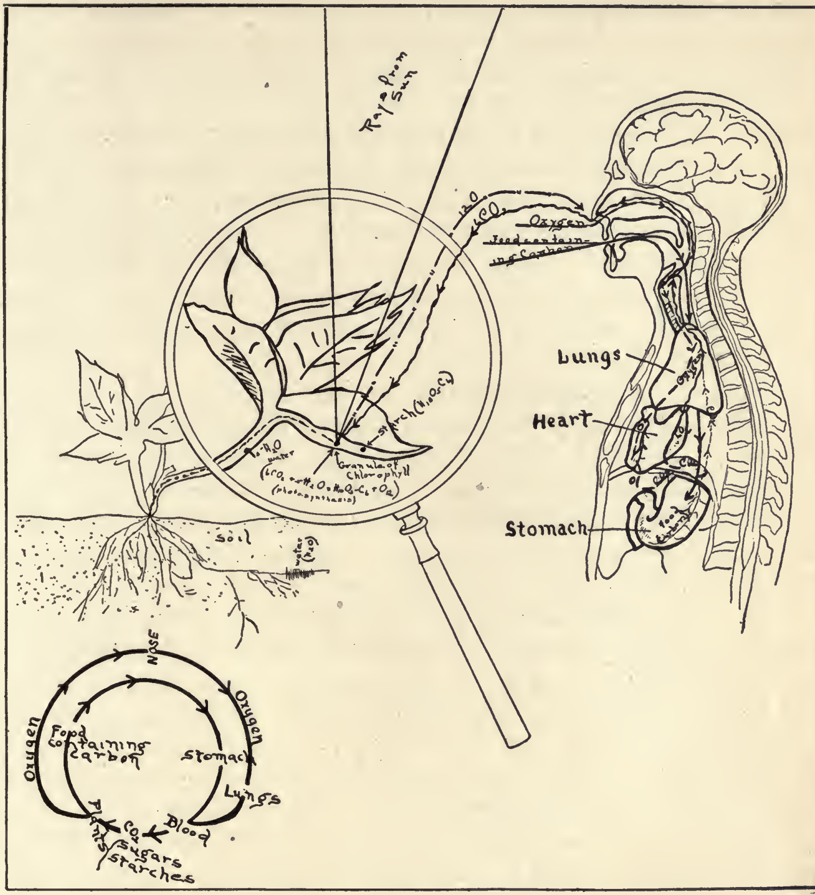


FIG. 142.—The Carbon Cycle. Why is it necessary to eat food containing carbon? Why is oxygen necessary? What is given off by expiration? Why must plants have CO_2? What does the plant take from the soil? What is produced from carbon dioxide and water in the plant? What is left over after starch is manufactured? What becomes of the oxygen which plants give off to the atmosphere? What is meant by the carbon cycle?

has circulated through the body and is dark red. Because of the large amount of carbon dioxide taken up, it passes through the arteries to the lungs, where the carbon dioxide is given off into the air sacs and expelled from the lungs into the air. The red corpuscles, after giving up the carbon dioxide, change to a bright red, due to an **enzyme** (that acts like chlorophyll, the green coloring matter of plants), which contains iron, and is the hemoglobin which we have already mentioned. When it takes up oxygen it is known as oxyhemoglobin. When the blood is light red the substance in the red corpuscles is known as oxyhemoglobin, and when the blood is dark red the substance in the red corpuscles is known as hemoglobin, since it has lost its oxygen.

Disposal of Carbon Dioxide in the Atmosphere.—Countless numbers of human beings, animals and fires are constantly giving off carbon dioxide. Without some check, therefore, it would not be long before the percentage of carbon dioxide in the atmosphere would increase enormously. Nature has provided a wonderful way to prevent the percentage of carbon dioxide from increasing to over .03 per cent (.0003) or .04 per cent (.0004).

The carbon dioxide of the atmosphere diffuses into the leaves and stems of plants. In the leaves there is a green coloring matter called **chlorophyll.** This chlorophyll absorbs certain light rays, and the energy obtained is used by the plants in uniting the carbon dioxide from the air with water which comes up from their roots to form starch. Hence, the excess carbon dioxide of the atmosphere is used up by plants in forming starch. This process of uniting water and carbon dioxide to form starch is called **photosynthesis.** (Photo meaning **light**; synthesis **to put together.**) Thus the starch is really manufactured by aid of the sunlight, through its agent chlorophyll.

How Starch is Manufactured.—All starch is composed of carbon, hydrogen and oxygen. Starch is usually composed of:

Six parts carbon (C_6),
Ten parts hydrogen (H_{10}),
Five parts oxygen (O_5).

Carbon dioxide and water, when put together by photosynthesis,

produce starch and oxygen. This oxygen is thrown off by the plant into the atmosphere for respiration and oxidation.

Digestion in Plants.—Since starch is manufactured in plants it must be changed into sugar by the process of digestion, just as the starch is changed into sugar in the human body. After the starch has been digested, that is, changed into sugar, it is dissolved and distributed throughout all the growing parts of the plants.

For every six parts of carbon dioxide ($6CO_2$), five parts of water unite with it, making in all

6C,
10H,
17O.

Now, starch has 6C, 10H, and 5O. Formula $C_6H_{10}O_5$. It will be readily seen that starch requires the 6C and the 10H, but only 5 of the 17O to make the compound. There will then be 12O left which the plant sends back to the atmosphere as a by-product for man and animal to use.

The manufacture of starch is expressed by the chemist in the formula $6CO_2+5H_2O$ changes to $C_6H_{10}O_5+6O_2$ (12O).

When the plant digests the starch, the formula

$$\underset{\text{Starch.}}{C_6H_{10}O_5}+H_2O \text{ changes to } \underset{\text{Sugar.}}{C_6H_{12}O_6}$$

tells us a little more water is added to form sugar.

Amount of Carbon Required for Growing Plants.—Without some consideration one hardly realizes the magnitude of the process, and the amount of carbon required for growing plants, when compared with the relatively small proportion of carbon in the atmosphere. It has been estimated that to every 10,000 quarts of air there are only 4 or 5 grams of carbon dioxide, which means about 2 grams of carbon. About one-half the weight of a plant in a dry state consists of carbon, and a single tree which has a dry weight of about 5 tons will have absorbed from the atmosphere about $2\frac{1}{2}$ tons of carbon. If 10,000 quarts of air contain only 2 grams of carbon and a single tree requires $2\frac{1}{2}$ million grams ($2\frac{1}{2}$ tons), there must necessarily have been a large amount of air deprived of carbon by one plant.

Nature has thus provided that plant life should help animal life, and that animal life should help plant life. An atom of carbon passes from a human being or animal to a plant, and from a plant back to the human being or animal in the form of food. Thus the cycle is complete.

Questions

1. What foods have you eaten to-day which contain (1) proteids, (2) fats, (3) carbohydrates?
2. Why should we chew our food well before swallowing?
3. Why does alcohol produce a great deal of heat in the body?
4. When could it be used as a medicine?
5. Why do the Eskimos eat a great deal of fatty food?
6. Why is it necessary to remove the carbon dioxide from the body?
7. Carbon monoxide unites with the hemoglobin of the blood. Why is this dangerous to life?
8. Why is the name "carbon cycle" applied to the process of keeping the air pure?
9. How many parts of oxygen does the process of breathing take from the atmosphere? (Refer to formula.)
10. How many parts of oxygen do plants return to the atmosphere?
11. Where does all the carbon come from which makes up nearly half the tree?
12. Name the sources of the carbon which has made the redwood trees of California. (About 4000 to 5000 years old.)
13. Name the possible sources of carbon in the food you eat to-day.
14. How do the winds assist us in keeping the air pure in winter?
15. Why is it objectionable to have plants in a sleeping room during the night?

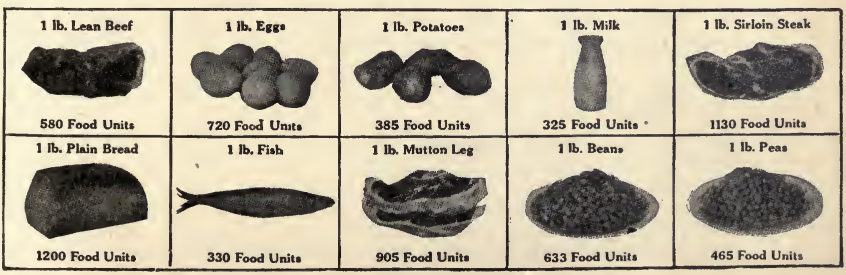
CHAPTER VII

FOOD AND MEDICINE

QUANTITY OF FOOD

Measurement of Food.—The body is like a blacksmith's forge; the lungs are the bellows, and the food the coal. Since the lungs furnish the blood with air which burns up the fuel that we digest, the value of a food depends upon the amount of heat energy and repairing ability which it supplies for the body. This is measured in **Calories.** A Calory here means the amount of heat required to raise 1 kilogram (1000 grams of water) 1° C. or about 1 pound of water 4° F. This Calory is written with a capital C, thus distinguishing it from the calory written with a small C (the amount of heat required to raise one gram of water 1° C.).

The Values of Food Vary.—Not all foods have the same number of Calories per pound. Some foods are very rich in food value, while others contain a small number of Calories; for example, a pound of raisins at 12 cents has as much food value in Calories as $3\frac{1}{2}$ pounds of lobster for $2.00. A pound of cornmeal flour has the same food value in Calories as $1\frac{1}{4}$ pounds of sirloin steak or 15 eggs. One would have to eat $9.00 worth of lettuce and tomato salad to furnish a day's requirement of Calories; while 30 cents worth of butter or 10 cents worth of sugar would give the same number of Calories.



COST OF 1000 CALORIES WITH REFERENCE TO THE DIFFERENT FOODS

The numbers represent the average number of 1000 Calories which may be purchased for prices over column.

Food.	0 to $0.50	$0.50 to 1.00	$1.00 to 1.50	$1.50 to 2.00	$2.00 to 2.50	$2.50 to 3.00	$3.00 to 3.50
Beans............	3						
Eggs.............	.....	3	3				
Fruits...........	.....	3	3	3	3	.....	3
Meats............	3	3	3				
Miscellaneous.....	3	3	3	.....	3	3	
Pastry and desserts	3	3	3				
Sandwiches.......	3	3	3	3			
Salads...........	.....	3	3				
Soups............	.....	3	3				
Oysters..........	2	3					
Dairy dishes......	3	3	3	3			
Fish.............	.....	3	3				3

	$3.50 to 4.50	$4.50 to 6.50	$6.50 to 7.50	$7.50 to 8.00	$8.00 to 9.00	$9.00 to 10.00	$10.00 to 10.50
Beans............							
Eggs.............							
Fruits...........	3	3	3	.....	.....	.....	3
Meats............							
Miscellaneous.....	.....	.....	.....	3	3	3	
Pastry and desserts							
Sandwiches.......							
Salads...........							
Soups............							
Oysters..........	.....	.....	.....	3			
Dairy dishes......							
Fish.............	.....	.....	3				

An example will make the table clear:

3000 Calories of fried oysters would cost................ $0.90
3000 Calories of raw oysters would cost.................. $7.84

3000 Calories are used in each case to represent the required number of Calories for a hard-working man.

3000 Calories of grape fruit cost........................ $5.65
3000 Calories of apples, baked........................... 1.05
3000 Calories of tomatoes................................ 9.60
3000 Calories of watermelon.............................. 3.65
3000 Calories of cantaloupe.............................. 10.33
3000 Calories of apple sauce............................. .77

Amount of Calories Required per Day.—Not all people require the same number of Calories of food. The following table shows the relation of different occupations to the amount of food required.

CALORIES OF FOOD CONSUMED DAILY *

Table is derived from data produced by Becket and Hamalainen of the University of Helsingfors, Finland, from actual experiment with individuals alternately resting and working at their respective trades while in the "respiration calorimeter."

Occupation.	Age.	Height, Ft.-Ins.	Weight, Pounds.	During Rest.		During Work.	Total Calories per Day (8 Hours' Work, 16 Hours' Rest).
				Calories per Hour.	Calories per Hour per Pound of Body Weight.	Calories per Hour.	
MEN							
Shoemaker....	56	5–0	145	73	.50	172	2544
Shoemaker....	30	5–8	143	87	.60	171	2760
Tailor.........	39	5–5	141	72	.50	124	2144
Tailor.........	46	5–10½	161	102	.63	135	2712
Bookbinder....	19	6–0	150	87	.58	164	2704
Bookbinder....	23	5–4½	143	85	.59	163	2664
Metal worker..	34	5–4	139	81	.58	216	3024
Metal worker..	27	5–5	130	99	.76	219	3336
Painter........	25	5–11	154	104	.67	231	3512
Painter........	27	5–8	147	111	.79	230	3616
Joiner.........	42	5–7	154	81	.50	204	2928
Joiner.........	24	5–5½	141	85	.60	244	3312
Stone-worker...	27	5–11	156	90	.57	408	4704
Stone-worker...	22	5–8	141	85	.60	366	4288
Sawyer........	42	5–5	167	86	.50	501	5384
Sawyer........	43	5–5	143	84	.59	451	4952
WOMEN							
Hand-sewer....	53	5–3	139	75	.54	83	1864
Hand-sewer....	35	5–6	143	64	.45	88	1728
Machine-sewer.	53	5–3	139	75	.54	103	2024
Machine-sewer.	19	5–3	110	64	.58	119	1976
Wash-woman..	43	5–3	125	75	.60	285	3480
Wash-woman..	19	5–3	110	64	.58	186	2512
Waitress......	43	5–3	125	75	.60	228	3024
Waitress......	19	5–3	110	64	.58	143	2168
Bookbinder....	22	5–4	105	70	.65	98	1904
Bookbinder....	22	5–3	112	61	.54	127	1992

From "How to Live." Copyright, Funk & Wagnalls, 1915.

It will be seen that people who do heavy work require a greater number of Calories than those who do light work, since a greater amount of the body tissues must be rebuilt, and a greater amount of energy must be obtained.

Food and Weight.—Often the weight of a person may be regulated by the type and kinds of food he eats, except in the earlier years of life. Overweight is a more unfavorable condition in its influence on longevity than underweight. Insurance companies have found that people who are slightly over weight before the age of 35 and slightly under weight after that age have a lower mortality than people who are under weight before 35 and over weight after that age. If a person belongs to a family with a tendency to overweight, that person should early begin to form habits that will counteract this tendency.

The following table will show the relation between overweight and the death rate for men at different ages.

MEN—OVER AVERAGE WEIGHTS

Experience of 43 America Companies—1885–1908.
Number of Policyholder 186,579

Ages at Entry.	Overweight 5 to 10 Pounds.		Overweight 15 to 20 Pounds.		Overweight 25 to 45 Pounds.		Overweight 50 to 80 Pounds.	
	Death Rate Below Standard.	Death Rate Above Standard.	Death Rate Below Standard.	Death Rate Above Standard.	Death Rate Below Standard.	Death Rate Above Standard.	Death Rate Below Standard	Death Rate Above Standard.
	Per Cent.	Per Cent.	Per Cent.	Per Cent.	Per Cent.	Per Cent.	Per Cent.	Per Cent.
20–24....	4	.....	4	.....	.....	1	.....	3
25–29....	7	.....	10	.....	.....	12	.....	17
30–34....	1	.....	14	.....	.....	19	.....	34
35–39....	0	.....	.....	1	.....	31	.....	55
40–44....	6	.....	.....	10	.....	40	.....	75
45–49....	.....	3	.....	9	.....	31	.....	51
50–56....	.....	2	.....	21	.....	24	.....	49
57–62....	.....	2	.....	25	.....	12	.....	38

The heaviest mortality (75 per cent above the standard) is found among those aged 40 to 44 who are 50 to 80 pounds overweight.

As fat cells do no work, the number of working cells in fat people is relatively less in proportion to the weight than in thin people. Also, there is less body surface exposed in proportion to the body weight, consequently less heat lost. Fat people are less active; therefore they do not need so much fuel or food. If they do consume as much food as thin people, the extra Calories are not burned up but are stored as fat.

Food to be Avoided by Overweights.—Sugar, fats, milk as a beverage, salmon, herring, mackerel, sardines, crabs, lobsters, pork, goose, fat meat, nuts, butter, creams, olive oil, pastry and sweets, water at meals—all these should be avoided by people who are over weight. Drugs or alcohol should never be used for reducing. The simplest way of reducing weight is to take plenty of exercise and eat the right kind of food.

Diet for Underweights.—Thin people lose heat more readily than stout people, as a large part of the active cells are on the surface and exposed. They require an abundant supply of food which will produce energy, such as fat, olive oil, and sugar used in other foods. Potatoes, bread, cereals, and starchy vegetables which are well masticated produce fat. Eggnogs are especially favorable as a food.

After the age of 35 one need not be concerned regarding underweight unless there is evidence of ill health.

Diet in Hot Weather.—The amount of food eaten in hot weather should be decreased because less food is required to maintain the heat of the body. Fatty foods and all other foods which produce large quantities of heat should be eaten sparingly. These foods are far more valuable during cold weather. Ice cream, which is often considered cooling, is really a great heat-producing food, since it contains large quantities of fatty substances.

Food and Work.—People who do heavy work should avoid eating heavy meals while they are tired, as a person in a tired condition is likely to be troubled with indigestion. Those who do considerable brain work should take plenty of exercise in order to use the fuel which through food is being stored up in the body. Brain workers do not require a special type of food, as is sometimes believed.

MEN—UNDER AVERAGE WEIGHT

Experience of 43 American Companies
Duration of Experience, 1885–1908
Number of Policyholders, 530,108

Ages at Entry.	Underweight, 5 to 10 Pounds.		Underweight, 15 to 20 Pounds.		Underweight, 25 to 45 Pounds.	
	Death Rate Below Standard.	Death Rate Above Standard.	Death Rate Below Standard.	Death Rate Above Standard.	Death Rate Below Standard.	Death Rate Above Standard.
	Per Cent.	Per Cent.	Per Cent.	Per Cent.	Per Cent.	Per Cent.
20–24.......	....	7	....	15	....	34
25–29.......	1	....	....	8	....	16
30–34.......	....	4	....	0	....	8
35–39.......	9	....	....	3	....	2
40–44.......	15	....	13	....	3	
45–49.......	3	....	1	....	11	
50–56.......	10	....	8	....	9	
57–62.......	7	....	18	....	19	

The most favorable mortality (19 per cent below the average) is found among those aged 57 to 62 who are extremely light in weight as compared with the average weight for those ages. The next lowest mortality in any other age group (15 per cent below the average) is among those aged 40 to 44 who are 5 to 10 pounds under the average weight.

Perfect Food.—A perfect food does not exist. A perfect food for a stout or sedentary person would not be a perfect food for an emaciated or active person. A person doing active work out of doors requires different food from that required by one who spends most of his time in the house.

A perfect food should

(1) be obtained at a reasonable price;

(2) be readily absorbed or digested without imposing undue strain upon the digestive system;

(3) have no waste;

(4) contain the necessary amount of cellulose to be porous and prevent unnecessary packing in the stomach and intestines.

(5) contain proteins, fats, carbohydrates, vitamines and water in the exact proportions which the body requires.

TABLES SHOWING AVERAGE HEIGHT, WEIGHT, SKIN SURFACE AND FOOD UNITS REQUIRED DAILY WITH VERY LIGHT EXERCISE

BOYS

Age.	Height in Inches.	Weight in Pounds.	Surface in Square Feet.	Calories or Food Units.
5	41.57	41.09	7.9	816.2
6	43.75	45.17	8.3	855.9
7	45.74	49.07	8.8	912.4
8	47.76	53.92	9.4	981.1
9	49.69	59.23	9.9	1043.7
10	51.58	65.30	10.5	1117.5
11	53.33	70.18	11.0	1178.2
12	55.11	76.92	11.6	1254.8
13	57.21	84.85	12.4	1352.6
14	59.88	94.91	13.4	1471.3

GIRLS

Age.	Height in Inches.	Weight in Pounds.	Surface in Square Feet.	Calories or Food Units.
5	41.29	39.66	7.7	784.5
6	43.35	43.28	8.1	831.9
7	45.52	47.46	8.5	881.7
8	47.58	52.04	9.2	957.1
9	49.37	57.07	9.7	1018.5
10	51.34	62.35	10.2	1081.0
11	53.42	68.84	10.7	1148.5
12	55.88	78.31	11.8	1276.8

MEN

Height in Inches.	Weight in Pounds.	Surface in Square Feet.	Proteids.	Calories or Food Units.		Total.
				Fats.	Carbohydrates.	
61	131	15.92	197	591	1182	1970
62	133	16.06	200	600	1200	2000
63	136	16.27	204	612	1224	2040
64	140	16.55	210	630	1260	2100
65	143	16.76	215	645	1290	2150
66	147	17.06	221	663	1326	2210
67	152	17.40	228	684	1368	2280
68	157	17.76	236	708	1416	2360
69	162	18.12	243	729	1458	2430
70	167	18.48	251	753	1506	2510
71	173	18.91	260	780	1560	2600
72	179	19.34	269	807	1614	2690
73	185	19.89	278	834	1668	2780
74	192	20.33	288	864	1728	2880
75	200	20.88	300	900	1800	3000

TABLES SHOWING AVERAGE HEIGHT, WEIGHT, SKIN SURFACE AND FOOD UNITS REQUIRED DAILY WITH VERY LIGHT EXERCISE—*Continued*

WOMEN

Height in Inches.	Weight in Pounds.	Surface in Square Feet.	Calories or Food Units.			
			Proteids.	Fats.	Carbohydrates.	Total.
59	119	14.82	179	537	1074	1790
60	122	15.03	183	549	1098	1830
61	124	15.29	186	558	1116	1860
62	127	15.50	191	573	1146	1910
63	131	15.92	197	591	1182	1970
64	134	16.13	201	603	1206	2010
65	139	16.48	209	627	1254	2090
66	143	16.76	215	645	1290	2150
67	147	17.06	221	663	1326	2210
68	151	17.34	227	681	1362	2270
69	155	17.64	232	696	1392	2320
70	159	17.92	239	717	1434	2390

NOTE. With active exercise an increase of about 20 per cent total food units may be needed.

Metabolism.—The process by which cells are nourished through the assimilation of food, while other cells are broken down to produce energy and heat, is called **metabolism.**

Even if we do not take nourishment enough, metabolism continues, thus using up the cells faster than they are built up. It is absolutely necessary that the process of metabolism be well balanced to keep the body in good condition.

QUESTIONS

1. What should a person know regarding a food besides its cost?

2. Why is not an expensive food more nourishing than a cheap food?

3. Name some foods which are cheap, but as nourishing as expensive foods.

4. Make a list of the foods you have eaten for a meal. List those that were expensive and those that were inexpensive.

5. How many Calories of food per day should you have? Your mother? Your father?

6. What foods must one over weight regard it as unwise to eat?

7. Are you under weight or over weight?

8. What foods are essential for underweights?

9. What other methods for reducing weight are advisable for overweights?

10. At what age is the death rate the highest for overweights? Lowest?

11. At what age is the death rate highest for underweights? Lowest?

12. Why is it necessary to change the diet for hot weather?

13. Why is ice cream a great heat-producing food?

14. What is the difference between the food eaten by manual workers and that eaten by brain workers?

15. What is the difference in the amount of exercise required for each?

16. What would be a perfect food?

17. What kind of a diet is a perfect diet for you?

18. Why is it necessary to eat a sufficient amount of food?

FOOD COMPOSITION

Food in General.—Foods may be divided and classified according to their richness into:

1. Protein, which builds up the tissues of the body.
2. Fat, which stores up fat in the body and produces heat.
3. Carbohydrates, which change into fat and produce energy.
4. Vitamines, the active, minute, crystalline substances which are the vital forces in food.
5. Mineral matter, which supplies the body with the necessary minerals for good health.

The per cent of protein eaten should be about 10 per cent, of fat 30 per cent, and of carbohydrates 60 per cent.

Protein.—Foods should be so selected as to give the correct number of Calories of protein. Protein must be regarded as building material, and no more should be eaten than is required to repair the tissues which have been worn out by the activity of the day. A person should eat at the most about 2½ ounces of protein, or about 200 Calories, each day, that is, 10 per cent of the total number

of Calories consumed. If a great amount of protein is eaten, waste matter, such as uric acid, and other poisonous substances are formed. Most foods contain protein. There are a few exceptions, such as butter, oleomargarine, oil, lard and cream, which consist of fat and water; and sugar syrups and starch, which consist of carbohydrates and water. Such foods as meat and eggs are very high in protein values. Cheap sources of proteins are beans, peanuts, skim milk and cheese.

Protein as Fuel for the Body.—The protein compounds are not only used for building and repairing tissue but are also burned directly in the body, like the carbohydrates, thus rendering important service as fuel. The protein can be so changed in the body as to yield fats and carbohydrates, and such changes actually occur to some extent. In this and in other ways they supply the body with fuel.

A dog can live on lean meat. He can convert its material into muscle and its energy into heat and muscular power. Man can do the same; but such a one-sided diet would not be best for the dog, and it would be still worse for man. The natural food for carnivorous animals like the dog supplies fats and some carbohydrates, and that for omnivorous animals like man furnishes fats and carbohydrates in liberal amounts, along with protein. Herbivorous animals, like horses, cattle, and sheep, naturally require large proportions of carbohydrates.

Fat.—Fats contain no nitrogen, but have a great deal of carbon and hydrogen which are easily oxidized, producing more energy than protein or carbohydrates.

A proper proportion of fats in food is about 30 per cent. Oils and fats have a good laxative tendency, but they cannot be taken in too large quantities without destroying the appetite. Cheap sources of fats are oleomargarine and cotton seed oil.

Carbohydrates.—Carbohydrate food is chiefly produced from plants, except milk. Candies, sugars, starches, molasses, honey, etc., are some of the best examples of carbohydrates. The chief sources of carbohydrates are sugar, starch, bread, potatoes, glucose, bananas, etc. These are great fat-producing as well as heat-producing foods.

COMMON FOODS CLASSIFIED*

	Poor in Fat.	Rich in Fat.	Very Rich in Fat.
Very high in Protein	White of eggs Codfish Lean beef Chicken Veal		
High in Protein	Shell-fish Skim milk Lentils Peas Beans	Most fish Most meats Most fowls Whole egg Cheese	
Moderate or Deficient in Protein	Most vegetables Bread Potatoes Fruits Sugar	Peanuts Milk Cream soups Most pies Doughnuts	Fat meats Yolk of eggs Most nuts Cream Butter

* "How We Live." Copyright, 1915, by Funk & Wagnalls.

Candies eaten between meals are not often regarded as food; and children may frequently be over-nourished by eating an excessive amount of sweets. It might be well to mention chocolate candy in connection with carbohydrate food. Chocolate candy should not be given to children in any considerable quantity. A substance called theobromine in the chocolate is too strong a stimulant for their delicate nervous systems. Since candy is considered a food, it should be made free from all adulterations, and, if colored, it should be colored with harmless dyes. A great deal of cheap poisonous candy which contains adulterations and material useless as food has been sold to children.

The use in candy of mineral substances, poisonous colors or flavors, or any injurious material is discouraged by all reputable candy manufacturers. Candies sweetened with saccharin, covered with shellac to keep moisture out, coated with talc, filled with earth or white clay in which glue has been used instead of gelatin, or

red oxide of iron used to represent chocolate, and ethers used for flavoring, should be avoided. It is better to spend a few cents more for good candy than many dollars for doctors. Synthetic ethers for flavoring should not be tolerated, since true fruit flavoring may be procured.

Candy digests very quickly; hence it is a food ready for use which can give a great deal of nourishment and energy to the body quickly. However, one does not feel satisfied for any length of time after eating a great deal of candy. It goes into the blood quickly and is soon used up. Foods which digest slowly are far better for the system, because nourishment is given as it is required. An excessive eating of candy produces fermentation or indigestion in the stomach, causing a feeling of nausea.

However, such great improvements have been brought about that many firms to-day are making candies which may be considered useful foods if eaten at the proper time and in correct proportions.

Soda Fountains.—People should beware of all soda fountains where saccharin is used as a substitute for sugar and ether used for flavoring to produce strawberry, raspberry, pineapple, etc. Flavorings and coal tar dyes are sometimes used in order to make the material look like a natural fruit product. Places where benzoate of soda, salicylic acid, or calcium bisulphide are used for preserving food material and refreshments are dangerous to public health. Sometimes caffeine is sold in soft drinks or beverages for imparting exhilarating effects. It is better not to indulge in such refreshments, for a drink habit may be acquired. There is danger of using in excess any habit-producing beverage. Over-stimulation by such drinks leads ultimately to nervous conditions and impaired health.

Vitamines.—Vitamines are minute crystalline substances. They are considered as vital forces in foods, and they cure diseases of nutrition. Raw and uncooked foods, such as lettuce, celery, tomatoes, fruits, milk, and all foods which have not been heated above the body temperature, contain vitamines. In foods which have been cooked, many of the vitamines are destroyed or diminished in value. They are exceedingly important to life. Many experiments made on pigeons and guinea pigs have shown that the health, and even the life, of the creature depended upon the vitamines present.

Scurvy has long been known to be associated with the use of a restricted diet lacking in fresh vegetables and meats. It frequently develops on shipboard when only bread foods and canned goods are used, also in times approaching famine. Fresh vegetables and fruits and their juices, and especially lime and lemon juices, have been recognized as remedies which bring about a rapid recovery. It is now believed that the recovery is due to a vitamine, or to several vitamines in the lemon juice and fresh vegetables.

Vitamines which Tend to Cure Diseases of the Nerves.		Vitamines which Tend to Cure Scurvy.	
Relatively Rich.	Relatively Poor.	Relatively Rich.	Relatively Poor.
Brewer's yeast	Sterilized milk	Fresh vegetables	Dried vegetables
Egg yolk	Sterilized meat	Fresh fruits	Dried fruits
Ox heart	Cabbage	Raw milk	Sterilized milk
Milk	Turnips	Raw meat	Canned meat
Beef and other fresh meat	Carrots and other vegetables of this type		Dried cereals
Fish	Highly milled cereals		Pork fat
Beans	Starch		
Peas	Pork		
Oats			
Barley			
Wheat			
Corn			

If bread is the main article of diet, it should be made of flour containing the bran; if rice, it should be the unpolished, since the coarse part of the cereal contains more vitamines. Beans, peas, and other legumes should be eaten at least once a week. Canned legumes are to be avoided, for canned goods usually have a less number of vitamines. Fresh vegetables or fruit should be used at least once or twice a week. Cereals (unhulled) should be included in all soups. When corn is the principal article of diet, the yellow meal, that is, that made from the whole grain, should be used. Potatoes and fresh meat should be used at least once a week, preferably daily. The use of preserved foods is to be avoided.

Mineral Matter.—Mineral matter is indispensable to the body because it forms about 5 or 6 per cent of the body weight. Such foods as fruits, vegetables, nuts, eggs, and baked potato skins contain large quantities of mineral matter. Mineral matter is used for forming bones, hair, teeth. It also aids in digestion and is found in the blood.

ESTIMATED AMOUNT OF MINERAL MATTER REQUIRED PER MAN PER DAY

	Grams.
Chlorine	6.00 –8.00
Sodium	2.97 –4.45
Potassium	1.66 –2.47
Phosphorus	1.31 –1.75
Sulphur	0.80 –1.40
Magnesium	0.18 –0.30
Calcium	0.50 –0.71
Iron	0.006–0.012

Food Containing Minerals.—Beans, peas, and lentils are rich in potassium, phosphorus, calcium, magnesium, and contain traces of iron, sulphur, silica, chlorin and sodium.

The cereals also have a great amount of mineral matter. Oats are the richest, barley next and wheat third; rye, corn and rice follow in this order.

Among the vegetables, spinach has the greatest amount of mineral matter, followed by cabbage, horse radish, lettuce, carrots, radishes, onions, cauliflower, cucumbers and asparagus. The green vegetables do not have very much protein and starch, with the exception of potatoes.

Among the dried fruits, dried figs are richest in mineral matter. Next to figs are blueberries, followed by strawberries, prunes, cherries, apples, peaches, gooseberries, and grapes. Apples and strawberries have a large percentage of sodium. Strawberries, gooseberries and prunes contain large amounts of iron. The strawberry leads in this list, and is also rich in silica.

Nuts are rich in phosphorus, potassium, magnesium and calcium.

Eggs contain a large percentage of sodium, calcium, iron, phosphorus and chlorin.

It will be seen that grains, fruits, and vegetables take up the various necessary minerals from the earth, forming compounds for animal life to assimilate from its food.

The skins of baked potatoes contain valuable mineral matter which may be used by the body.

Elements of the Human Body.—A man weighing 160 pounds possesses in his body about

45 pounds of carbon,
15 pounds of hydrogen,
90 pounds of oxygen,
$3\frac{1}{2}$ pounds of calcium,
$1\frac{1}{2}$ pounds of phosphorus
$1\frac{1}{2}$ pounds of chlorin,
$3\frac{1}{2}$ ounces of sulphur,
$3\frac{1}{2}$ ounces of fluorine,
3 ounces of potassium,
$2\frac{1}{2}$ ounces of sodium,
2 ounces of magnesium,
$1\frac{1}{2}$ ounces of iron,
1 ounce of silica,
$\frac{1}{2}$ ounce of manganese.

About 60 to 70 per cent of the human body is made up of water. (Hydrogen and Oxygen.)

FOOD COMPOSITION AND USE IN THE BODY

Kind.	Composed of.	Use.	Food Chiefly Found in
Proteids	Carbon Hydrogen Nitrogen Sulphur Phosphorus (sometimes)	Build tissues	White of eggs, curd of milk, lean meat, gluten of wheat, fish, chicken, etc.
Fats	Carbon Hydrogen Oxygen	For producing heat or for storing as fat.	Butter, olive oil, oils of corn and wheat, cheese, fat meat, etc.

Carbohydrates	Carbon Hydrogen Oxygen	For producing heat, or transformation into fats	Sugars, starches
Mineral Matter (Ash)	Sulphur Phosphorus Chlorine Sodium Potassium Calcium Magnesium Iron Silica	Aiding digestion, forming of bones, blood, hair, teeth.	Potato skins, fruits, vegetables, nuts, eggs
Vitamines	Minute crystalline substances Destroyed or diminished by cooking except in acid fruit and acid vegetables	Vital force in foods. Cure diseases of nutrition	Raw and uncooked foods such as lettuce, celery, tomatoes, fruits and milk All food which has not been heated above body temperature

Questions

1. What are the essential materials in foods?

2. How many Calories of protein, carbohydrates and fats should you eat each day?

3. Why is eating protein food to excess unwise?

4. What foods are especially rich in protein? in carbohydrates? in fats?

5. What are the cheap sources of protein? carbohydrates? fats?

6. Why is a meat diet unhealthy?

7. Will a vegetable diet give the required number of Calories of each food-element?

8. What is the best diet?

9. Why do Eskimos require fatty foods?

10. Why should candy be called a food?

11. Why should we eat some raw foods?

12. Why are fruits, nuts and eggs essential foods for the body?

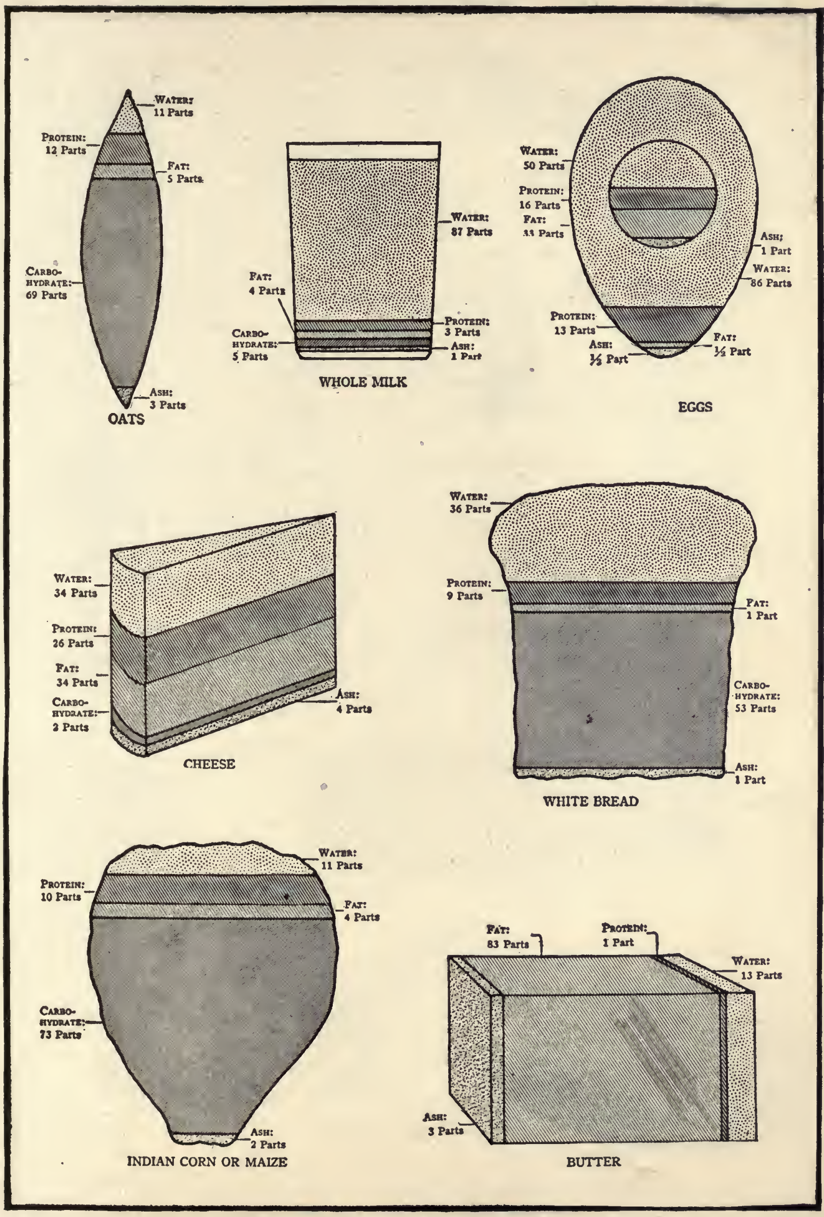


FIG. 143.—How do the above classes of food differ from meats and vegetables?

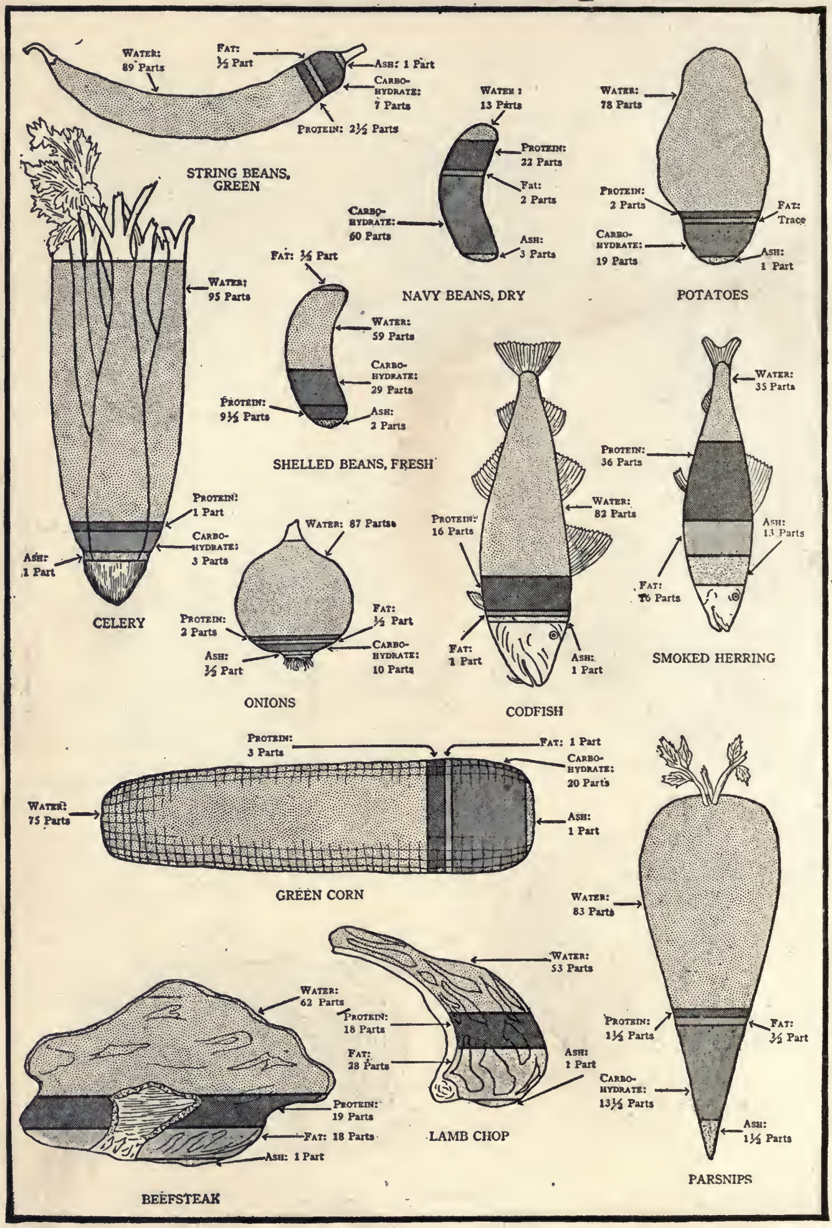


Fig. 144.—What foods are richest in protein, carbohydrates, fats, mineral matter? Why should vegetables be eaten with meats?

13. What foods contain minerals?

14. How many Calories of protein, fat, or carbohydrates did you eat yesterday? What is the total? What amount of protein in excess did you eat, if any?

15. Make out a diet for one day which will be very cheap.

16. Make out a list of foods which would be very expensive for a day's supply.

17. How does a vegetarian obtain the necessary number of Calories of protein?

18. What is a well-balanced diet?

19. How does milk compare with eggs in food value?

20. How does a pound of nuts compare in food value with a pound of meat? Which is cheaper?

21. Compare rice, wheat, peas, and beans as to food value and cost. (Obtain cost from your grocer.)

22. What is the most valuable thing you have learned in this section?

Daily Food Chart.—From the following table make out a food chart of the food you have eaten for several days. Determine

1. Number of Calories of protein eaten daily;
2. Number of Calories of fat eaten daily;
3. Number of Calories of carbohydrates eaten daily;
4. By multiplying your weight by 16.1, compute the number of Calories of food you should eat.
5. Compute the number of Calories of protein you should eat;
6. Compute the discrepancies.

FOOD TABLE*

Name of Food	Constituents: Food	Constituents: Gm.	Calories in Sample: Protein Nutritional	Calories in Sample: Fat	Calories in Sample: Carbohydrate	Nutritional Calories from Bread and Butter	Nutritional Calories per Portion
						%	
Apple, baked	One serving	114.9	1.0	1.2	134.6	....	136.8
Apple, baked (with cream)	One serving	228.8	4.1	11.0	376.9	....	39.2
Apple, baked (with ice cream)	One serving	206.3	9.0	50.3	212.7	....	27.2
Apple fritters with fruit sauce	One serving	155.9	18.9	129.4	175.1	....	323.4
Apple sauce with whipped cream	One serving	154.7	2.7	31.7	109.8	....	144.3
Apple sauce	One serving	111.0	2.0	5.0	93.0	....	100.0
Apricots	One serving	131.0	....	......	......	....	100.0
Artichokes	One serving	86.0	2.8	10.0	17.2	....	20.0
Apricots	One serving	131.0	6.0	0.0	94.0		
Asparagus, creamed on toast	Toast	35.2	32.5	54.5	109.8	....	196.8
	Asparagus	210.6					
Bacon, broiled	Bacon	40.7	50.4	439.9	250.7	34.3	741.0
	Potatoes	70.2					
	Bread plus butter	74.2					
Bacon and eggs	Bacon	32.7	106.3	415.1	254.9	29.8	776.3
	Eggs	74.8					
	Potatoes	68.5					
	Bread plus butter	67.6					
Bacon, fried, with French fried potatoes	Bacon	44.3	67.6	516.4	248.4	....	832.4
	Potatoes	51.8					
	Rolls	84.9					
	Butter	11.4					
Bananas, sliced	One serving (edible)	104.2	4.0	000.0	85.9	....	89.9
Bananas, sliced with cream	Bananas (edible)	123.9	10.9	133.2	108.2	....	258.3
	Cream	61.5					
Beans, baked with macaroni	Beans	140.8	91.1	104.4	391.8	....	587.3
	Macaroni	119.2					
Beans, Boston baked (average 6 orders)	Beans (average)	207.2	73.3	141.5	265.8	34.2	460.6
	Per cent variation	+12.3%	....	+83.5%	+21.0%		
	from average	−15.6%	....	−61.3%	−22.8%		
	Bread and butter (average)	48.0					
	Per cent variation	+14.4%					
	from average	− 9.0%					
Beans, Boston (on the side)	One serving	77.0	24.0	29.8	79.9	....	133.7
Beans, kidney	One serving	92.0	24.9	165.8	68.0	....	258.8
Beans, New York baked (average 7 orders)	Beans (average)	191.2	77.7	112.1	269.6	35.5	459.4
	Per cent variation	+33.2%	....	+79.6%	+18.8%		
	from average	−28.7%	....	−38.8%	−23.9%		
	Bread and butter (average)	47.7					
	Per cent variation	+10.0%					
	from average	−11.0%					
Beans, New York (on the side)	One serving	130.9	42.5	70.7	110.2	....	223.4
Beans, New York baked, with tomato sauce	Beans and sauce	197.8	70.0	75.6	257.4	34.8	430.0
	Bread and butter	40.9					
Beans, string	One serving	96.0	3.0	9.6	7.4	....	20.0
Beef cakes with brown gravy and macaroni	Cakes, macaroni and gravy	339.5	89.9	225.0	359.5	35.1	674.4
	Bread and butter	69.2					
Beef, chipped and scrambled eggs	Beef and eggs	135.4	123.7	354.9	252.2	36.4	730.8
	Potatoes	61.4					
	Bread and butter	77.8					
Beef, corned	Beef	68.3	99.2	182.0	116.0	45.8	397.2
	Bread and butter	53.2					

* Adaptation of Gebphart and Lusk Analysis of Foods, American Medical Association and Atwater's tables.

FOOD TABLE—*Continued*

Name of Food	Constituents		Calories in Sample			Nutritional Calories from Bread and Butter	Nutritional Calories per Portion
	Food	Gm.	Protein Nutritional	Fat	Carbohydrate		
						%	
Beef, corned, and Boston beans....	Beef.............	40.6	97.2	149.3	253.7	48.6	500.2
	Beans...........	102.6					
	Bread and butter.	71.1					
Beef, corned, and New York beans...	Beef hash........	96.8 ?	102.4	144.3	290.7	....	537.4
	Beans...........	156.3					
	Bread and butter.	98.6 ?					
Beef, corned, hash with poached egg.	Beef hash........	134.8	113.0	312.6	210.1	35.5	355.7
	Egg.............	42.3					
	Bread and butter.	65.9					
Beef, corned, hash browned in pan..	Hash............	123.9	70.0	207.6	233.2	46.1	510.8
	Bread and butter.	68.9					
Beef, corned, hash browned with two poached eggs	Hash............	157.1	113.9	377.5	259.3	37.7	750.7
	Bread and butter.	82.6					
	Eggs............	63.1					
Beef, corned, hash (steamed).......	Hash............	149.4	65.7	185.2	257.1	55.8	508.0
	Bread and butter.	82.8					
Beef, corned, hash (steamed) with poached egg	Hash and egg.....	148.5	101.7	219.0	214.5	44.3	535.2
	Bread and butter.	69.3					
Beef, corned, with potato salad.....	Beef............	29.9	68.6	137.0	223.8	53.1	429.4
	Potato salad.....	114.6					
	Bread and butter.	66.5					
Beef, creamed chipped............	Beef, etc.........	210.2	115.0	148.0	228.2	51.7	491.2
	Bread and butter.	73.7					
Beef, creamed chipped, on toast....	Beef............	89.4	122.3	324.4	300.9	....	747.6
	Sauce...........	94.3					
	Toast...........	32.9					
	Rolls............	75.8					
	Butter..........	12.8					
Beef, roast, cold..................	Roast beef.......	79.2	111.8	154.2	154.3	63.4	420.3
	Bread and butter.	77.8					
Beef, roast, croquettes with macaroni	Croquettes.......	85.2	82.8	211.9	330.3	34.3	625.0
	Macaroni........	93.1					
	Mashed potatoes..	123.5					
	Bread and butter.	62.7					
Beef, roast, croquettes with spaghetti	Croquettes.......	113.7	76.8	188.8	283.4	....	549.0
	Spaghetti........	102.6					
	Potatoes.........	126.4					
Beef, roast, cutlet, mashed potatoes.	Beef cutlet.......	112.4	93.2	265.6	258.2	38.3	617.0
	Potatoes and gravy	122.6					
	Bread and butter.	69.1					
Beef, roast, cutlet with tomato sauce.	Cutlet...........	121.8	121.2	318.1	300.3	38.4	739.6
	French fried potatoes and tomato sauce.........	85.4					
	Bread and butter.	83.0					
Beef, roast, hash, browned.........	Hash............	196.8	89.2	301.0	276.1	36.9	666.3
	Bread and butter.	71.9					
Beef, roast, with potato salad......	Beef............	70.3	102.8	178.7	255.6	43.9	537.1
	Potato salad.....	151.2					
	Bread and butter.	68.8					
Beef, roast sirloin of, and mashed potatoes	Beef............	72.6	101.8	141.4	256.4	44.8	499.6
	Potatoes and gravy	164.5					
	Bread and butter.	65.4					
Blackberries and cream...........	Blackberries (sugared).........	108.5	11.2	96.7	112.9	....	220.8
	Cream...........	60.0					
Beets..........................	One serving......	82.0	0.6	7.6	25.0	....	33.2
Beef tongue.....................	One serving......	57.0	24.0	97.0	0.0	....	121.0
Blueberries, canned..............	1 oz.............	28.3	.9	5.4	63.9	....	70.2

FOOD TABLE—*Continued*

Name of Food	Constituents		Calories in Sample			Nutritional Calories from Bread and Butter	Nutritional Calories per Portion
	Food	Gm.	Protein Nutritional	Fat	Carbohydrate		
						%	
Biscuit, cream	One serving	66.0	21.5	68.8	119.0	....	209.3
Biscuit, homemade	One serving	56.7	19.5	26.0	116.8	....	162.3
Biscuit, soda	One serving	56.7	22.0	61.0	113.4	....	197.1
Bread, gluten	One slice	56.7	20.4	7.6	112.2	....	140.3
Bread, graham	One slice	50.0	16.8	7.1	104.2	....	128.1
Bread, homemade	One slice	47.5	16.2	7.5	91.2	....	114.9
Bread, plain roll	One	56.7	21.5	20.4	136.0	....	177.9
Bread, rye	One slice	56.7	26.0	2.5	80.5	....	109.1
Bread, whole wheat	One slice	56.7	21.5	5.1	112.2	....	138.8
Bread and butter	One slice	70.8	24.9	122.4	133.8	....	281.2
Bread, hot corn	One serving	153.2	43.5	104.3	309.3	....	457.1
Bulgarzoon	One serving	201.3	26.5	76.0	29.6	....	132.1
Buns, bath	One serving	96.5	32.0	91.3	234.2	....	351.5
Butter	One pat	10.0	0.4	76.5	0.0	....	76.9
Cabbage, boiled	One serving	62.0	4.0	1.6	14.4	....	20.0
Cakes, buckwheat, with country sausage	Cakes	135.3	93.0	351.8	174.1	....	618.9
	Sausage	70.6					
	Butter	16.0					
Cakes, buckwheat, with maple cane syrup	Cakes	145.1	36.0	67.2	313.3	....	416.5
	Syrup	43.8					
Cakes, butter (average 2 orders)	One serving	96.2	33.1	71.3	173.6	....	278.0
	Per cent variation from average	+5.5% −5.5%	....	+5.8% −5.8%	+8.9% −8.9%		
Cake, chocolate, spiced	One serving	95.2	16.6	85.7	221.7	....	324.0
Cake, cocoanut	One serving	53.7	13.1	79.6	111.9	....	204.6
Cake, coffee	One serving	82.4	24.6	72.8	192.8	....	290.2
Cakes, cornmeal, with maple cane syrup	Cakes	174.4	38.5	143.6	368.2	....	550.3
	Syrup	37.4					
Cake, banana layer	One serving	83.4	16.9	76.0	160.5	....	253.4
Cake, chocolate layer	One serving	65.6	14.8	47.5	150.1	....	212.4
Cake, frosted	One serving	56.7	13.6	45.9	147.6	....	207.1
Cake, fruit	One slice	57.0	15.0	54.0	144.0	....	213.0
Cake, nut	One slice	71.0	23.0	135.0	156.0	....	314.0
Cake, walnut layer, with marshmallow icing	Total sample	84.1	23.3	99.5	200.4	....	323.2
Cake, old-fashioned molasses	One serving	82.7	17.7	62.2	202.0	....	281.9
Cake, pound	One serving	87.0	25.8	146.5	210.6	....	382.9
Cakes, rice, with maple cane syrup	One serving	270.3	47.0	146.7	363.1	....	556.8
Cake, sponge	One slice	27.5	7.7	27.5	74.8	....	110.0
Cakes, wheat, with maple cane syrup (average 6 orders)	One serving (av.)	188.2	35.8	108.5	317.8	....	462.1
	Per cent variation from average	+15.6% −13.3%	....	+18.3% −30.0%	+15.7% −8.8%		
Cantaloupe	Edible portion	127.0	2.9	......	33.3	....	36.2
Carrots	One serving	82.0	5.0	17.0	28.0	....	50.0
Cauliflower	One serving	62.0	4.6	3.0	12.4	....	20.0
Celery	One serving	27.0	1.2	0.2	3.6	....	5.0
Cherries, fresh	1 oz.	28.3	1.0	2.0	18.0	....	21.0
Cranberries, fresh	1 oz.	28.3	0.4	1.5	11.2	....	13.1
Currants, dry	1 oz.	28.3	2.7	4.3	84.0	....	91.0
Currants, fresh	1 oz.	28.3	1.9	0.0	14.4	....	16.3
Champagne	One serving	375.5	267.8	......	77.1	....	344.9
Charlotte russe	One serving	43.5	12.4	71.5	72.6	....	156.5
Cheese, Am. pale	1.5 cu. in.	22.0	25.0	73.0	2.0	....	100.0
Cheese, cottage	2 cu. in.	44.5	39.0	4.0	8.0	....	50.0
Cheese, full cream	1.5 cu. in.	23.0	25.0	73.0	2.0	....	100.0
Cheese, Neufchatel	1.5 cu. in.	29.5	22.0	76.0	2.0	....	100.0
Cheese, pineapple	1.5 cu. in.	20.0	25.0	73.0	2.0	....	100.0
Cheese, Swiss	1.5 cu. in.	23.0	25.0	74.0	1.0	....	100.0
Chicken, broiler	One serving	90.7	79.0	21.0	0.0	....	100.0

FOOD TABLE—*Continued*

Name of Food	Constituents: Food	Constituents: Gm.	Calories in Sample: Protein Nutritional	Calories in Sample: Fat	Calories in Sample: Carbohydrate	Nutritional Calories from Bread and Butter	Nutritional Calories per Portion
						%	
Chicken, creamed, on toast........	Chicken and toast.	160.7	73.5	88.5	209.4	37.5	371.4
	Bread and butter.	40.6					
Chicken croquette and French fried potatoes	Croquette........	87.4	55.7	200.9	221.3	....	477.9
	Potatoes.........	96.1					
Chicken cutlet with mashed potatoes	Cutlet...........	86.5	72.5	163.7	337.5	57.6	573.7
	Potatoes.........	105.5					
	Bread and butter.	96.4					
Chicken giblets on toast...........	Giblets and toast.	177.2	156.4	158.6	297.1	41.5	612.1
	Potatoes.........	124.2					
	Bread and butter.	74.3					
Chicken hash.....................	Hash............	124.3	69.8	183.4	187.6	46.3	440.8
	Bread and butter.	59.6					
Chicken wings on toast............	Total edible chicken.........	388.6	205.0	184.1	283.7	38.2	672.8
	Toast and potatoes, bread and butter..........	75.0					
Chicken fricasseed................							
Clams............................	One average......	14.2	5.7	0.8	0.3	....	6.8
Clam chowder....................	Chowder.........	413.2	69.0	41.2	292.2	....	402.4
	Crackers.........	46.0					
Cocoa...........................	One serving......	257.3	23.7	67.5	156.3	....	247.5
Codfish, creamed, on toast (average 2 orders)	Codfish (average).	152.8	111.8	157.0	255.2	46.3	524.0
	Per cent variation	+4.1%	....	+20.5%	+3.9%		
	from average....	−4.1%	....	−20.5%	−3.9%		
	Toast (average)...	44.1					
	Per cent variation	+6.1%					
	from average....	−6.1%					
	Bread and butter (average).......	70.8					
	Per cent variation	+14.4%					
	from average....	−14.4%					
Cookies, molasses.................	One.............	50.0	15.0	44.0	15.2	....	211.0
Cookies, sugar....................	One.............	43.0	12.0	37.0	125.0	....	174.0
Coffee, cup of, containing cream and sugar	One serving......	327.8	19.8	23.2	152.2	....	195.2
Corn, canned....................	Side dish.........	89.1	11.7	9.0	69.3	....	90.0
Corn, stewed....................	One serving......	70.1	5.0	3.8	43.7	....	52.5
Corn flakes and milk..............	Corn flakes	19.3	39.3	83.2	99.6	....	222.1
	Milk............	233.5					
Cornstarch, chocolate, with cream..	One serving......	160.5	19.7	117.2	94.7	....	231.6
Cornstarch, chocolate, with whipped cream	One serving......	160.9	11.7	9.5	138.4	....	159.6
	Cream lost.......						
Cornstarch, strawberry, with whipped cream	One serving......	119.7	1.0	5.1	96.1	....	102.2
Cornstarch, vanilla, with cream....	One serving......	172.2	18.7	26.8	161.0	....	206.5
Crab, deviled (average 2 orders)....	Crab (edible) (av.)	81.4	61.0	106.2	195.5	64.1	362.7
	Per cent variation	+11.8%	....	+ 9.5%	+10.0%		
	from average....	−11.8%	....	− 9.5%	−10.0%		
	Bread and butter (average).......	67.8					
	Per cent variation	+0.6%					
	from average....	−0.6%					
	Water cress (av.) .	15.4					
	Per cent variation	+26.5%					
	from average....	−26.5%					
Crackers, graham (average 3 to order)	One serving (av.).	51.8	51.8	49.2	159.6	....	223.3
	Per cent variation	+2.5%	....	+1.6%	+3.0%		
	from average....	−5.3%	....	−3.2%	−6.0%		

FOOD TABLE—*Continued*

Name of Food	Constituents: Food	Constituents: Gm.	Calories in Sample: Protein Nutritional	Calories in Sample: Fat	Calories in Sample: Carbohydrate	Nutritional Calories from Bread and Butter	Nutritional Calories per Portion
						%	
Crackers, oatmeal	One	12.5	5.5	12.0	32.5	....	50.0
Crackers, saltines	One	2.3	0.8	1.9	6.6	....	9.3
Crackers, soda (Uneeda biscuit)	One	6.9	2.6	5.9	20.0	....	28.5
Crackers, milk	One serving	72.6	24.0	80.3	212.8	....	317.1
Crackers, milk, and milk	Crackers	70.8	57.6	157.1	246.3	....	461.0
	Milk	226.9					
Crackers, soda, and milk	Crackers	52.5	51.4	131.9	193.9	....	377.2
	Milk	238.7					
Cream	One serving	239.0	25.5	450.3	30.1	....	505.9
Cream roll	One serving	47.4	13.5	116.4	95.2	....	225.1
Cream of wheat	One serving	205.9	23.6	0.6	101.7	....	125.9
Crullers	One serving	110.7	33.0	168.2	242.8	....	444.0
Cucumbers	Side dish	56.5	1.8	1.0	7.2	....	10.0
Custard, baked apple, with whipped cream	One serving	193.9	16.3	38.3	208.3	....	262.9
Custard, cup	One serving	189.7	38.3	50.4	130.3	....	219.0
Dates, dried	1 oz.	28.3	2.1	6.4	80.0	....	88.5
Doughnuts	One	56.7	15.1	107.1	120.4	....	242.6
Dressing, salad, French	1 spoonful	15.0	0.0	189.0	3.2	....	192.2
Dressing, mayonnaise	1 spoonful	36.0	8.0	81.0	4.0	....	93.0
Eclair, chocolate	One serving	74.9	13.8	48.3	125.9	....	188.0
Eggs, boiled (2)	Eggs	91.6	66.6	189.7	108.5	....	364.8
	Toast and butter	42.0					
Eggs, creamed on toast	Creamed eggs	193.6	105.2	258.9	258.4	37.6	622.5
	Toast	48.4					
	Bread and butter	68.3					
Eggs, fried (2) (average 2 orders)	Eggs (average)	84.7	76.0	229.9	192.2	58.1	498.1
	Per cent variation	+9.9%	....	+5.5%	+16.2%		
	from average	−9.9%	....	−5.5%	−16.2%		
	Bread and butter (average)	84.5					
	Per cent variation	+14.4%					
	from average	−14.4%					
Egg plant fried in butter	One serving	154.0	35.2	396.5	194.3	....	626.0
Eggs, poached on toast (2)	Eggs	83.1	60.7	83.3	118.4	....	262.4
	Toast	48.3					
Eggs, scrambled (2)	Eggs	64.6	56.5	230.1	152.3	52.6	438.9
	Bread and butter	67.6					
Fish, blue	One serving	140.0	107.2	15.1	0.0	....	182.3
Fish cakes with macaroni	Cakes	143.7	76.9	136.7	294.0	....	507.6
	Macaroni	91.4					
	Bread and butter	58.1					
Fish cakes with poached egg	Fish cakes	118.1	93.0	190.3	284.0	53.2	567.3
	Poached egg	44.3					
	Bread and butter	88.1					
Fish cakes with spaghetti	Fish cakes	122.8	77.9	100.8	303.7	54.0	482.4
	Spaghetti	141.2					
	Bread and butter	76.1					
Fish cakes with tomato sauce	Fish cakes	153.6	58.2	154.0	271.5	54.4	483.7
	Bread and butter	76.9					
Fish, cod, fresh	One serving	140.0	95.2	6.3	0.0	....	107.3
Fish, cod, salted	One serving	140.0	155.9	3.7	0.0	....	159.6
Fish, halibut	One serving	85.0	66.1	42.9	0.0	....	110.0
Fish, herring, smoked	One serving	57.0	83.6	80.6	0.0	....	164.2
Fish, salmon, canned	One serving	55.0	47.9	59.4	0.0	....	107.3
Fish, salmon, lake	One serving	55.0	39.1	50.9	0.0	....	90.0
Fish, sardines	One serving	30.0	27.6	53.1	0.0	....	80.7
Fish, shad	One serving	65.5	50.6	59.4	0.0	....	110.0

FOOD TABLE—*Continued*

Name of Food	Constituents: Food	Constituents: Gm.	Calories in Sample: Protein Nutritional	Calories in Sample: Fat	Calories in Sample: Carbohydrate	Nutritional Calories from Bread and Butter	Nutritional Calories per Portion
						%	
Fish, trout	One serving	85.0	66.7	16.7	0.0	....	83.4
Frankfurters and potato salad	Frankfurters	65.4	81.9	244.3	261.5	42.5	587.7
	Potato salad	158.6					
	Bread and butter	72.9					
Gingerbread	One serving	54.0	12.0	46.0	142.0	....	200.0
Grapes	1 oz.	28.3	1.1	3.3	16.0	....	20.4
Grape fruit	Edible portion	189.3	4.6	......	72.7	....	77.3
Gravy, brown	Large serving	64.0	3.6	8.4	60.2	....	72.2
Goose	One serving	50.0	32.0	168.0	0.0	....	200.0
Ham, broiled	Ham	90.2	113.5	478.5	300.2	....	892.2
	Bread	67.7					
	Potatoes	106.6					
Ham, cold	Ham	65.6	62.2	366.6	121.6	39.6	550.4
	Bread and butter	63.7					
Ham croquettes	Croquettes	82.1	78.1	197.5	250.5	32.7	536.1
	Mashed potatoes and gravy	166.3					
	Bread and butter	50.2					
Ham, fried	Ham	63.6	86.6	204.6	143.0	49.6	434.2
	Bread and butter	62.7					
Ham and beans (Boston)	Ham	42.6	87.9	256.1	260.0	44.6	604.0
	Beans	107.6					
	Bread and butter	78.8					
Ham and beans (New York)	Ham	35.9	107.4	115.5	396.9	40.2	619.8
	Beans	176.9					
	Bread and butter	72.8					
Ham and eggs (average 9 orders)	Ham (average)	53.7	130.6	411.9	248.7	29.8	791.2
	Per cent variation	+40.0%	....	+11.2%	+41.5%		
	from average	−26.3%	....	−19.2%	−31.0%		
	Eggs (average)	73.5					
	Per cent variation	+20.5%					
	from average	−21.8%					
	Potatoes (average)	79.0					
	Per cent variation	+58.3%					
	from average	−33.6%					
	Bread and butter (average)	68.9					
	Per cent variation	+27.4%					
	from average	−21.6%					
Ham, minced, and scrambled eggs	Ham and eggs	116.8	90.8	402.1	234.8	35.5	727.7
	French fried potatoes	72.4					
	Bread and butter	75.4					
Ham and potato salad	Ham	67.7	83.7	317.0	231.8	31.1	632.5
	Potato salad	177.5					
	Bread and butter	57.5					
Hominy	One dish	118.6	11.0	2.0	87.0	....	100.0
Honey	One t.s.p.*	7.5	0.3	0.0	24.0	....	24.3
Huckleberries	One serving	86.0	2.4	5.4	60.0	....	67.8
Ice cream, strawberry	One serving	105.3	10.7	106.7	86.7	....	204.1
Ice cream, vanilla	One serving	134.8	15.7	118.3	93.5	....	227.5
Jelly, pineapple fruit, with whipped cream	One serving	110.7	9.7	40.3	59.8	....	109.8
Jelly, strawberry fruit, with whipped cream	One serving	128.2	2.3	34.2	118.4	....	154.9
Jelly, cherry	1 t.s.p.	29.0	2.0	0.0	24.0	....	26.0
Jelly, cranberry	1 spoonful	57.0	2.0	4.5	96.0	....	102.5

* t.s.p. one teaspoon

FOOD TABLE—*Continued*

Name of Food	Constituents: Food	Constituents: Gm.	Calories in Sample: Protein Nutritional	Calories in Sample: Fat	Calories in Sample: Carbohydrate	Nutritional Calories from Bread and Butter	Nutritional Calories per Portion
						%	
Jelly, currant	1 t.s.p.	29.0	2.0	0.0	88.0	....	90.0
Jelly roll	1 slice	86.0	16.0	28.0	250.0	....	294.0
Kumyss	.67 oz	18.8	2.1	3.7	4.2	....	10.0
Lady fingers	One serving	13.5	5.0	6.0	39.0	....	50.0
Lamb chops (2)	Chops (edible)	55.0	105.2	365.8	340.6	....	811.6
	Potatoes	85.1					
	Toast and butter	18.5					
	Bread and butter	71.3					
Lamb chops breaded with mashed potatoes	Chops (edible)	42.6	61.3	249.6	219.9	48.6	530.8
	Potatoes and gravy	111.1					
	Bread and butter	75.4					
Lamb croquettes and mashed potatoes	Croquettes	134.9	112.6	426.0	335.6	29.5	874.2
	Potatoes and sauce	189.0					
	Bread and butter	75.4					
Lamb cutlet with mashed potatoes	Cutlet	99.5	90.7	252.8	272.7	36.9	616.2
	Potatoes	120.6					
	Bread and butter	66.5					
Lamb pie, baked, individual	Pie	213.5	127.9	204.6	230.7	46.6	563.2
	Bread and butter	76.7					
Lemonade, without sugar	1 glass	30.7	0.0	0.0	13.0	....	13.0
Lentils, cooked	One serving	89.0	27.0	1.0	72.0	....	100.0
Lettuce	One serving	25.0	1.2	0.7	3.0	....	4.9
Liver and bacon	Liver	63.9	127.5	334.6	285.1	36.4	747.2
	Bacon	16.3					
	Bread and butter	79.4					
	Potatoes	85.4					
Liver and bacon with Lyonnaise potatoes	Liver	127.3	151.4	299.7	303.9	29.7	755.0
	Bacon	20.6					
	Potatoes	155.9					
	Bread and butter	65.6					
Liver and onions with French fried potatoes	Liver	51.8	97.5	398.6	304.1	....	800.2
	Onions and gravy	55.5					
	French fried potatoes	57.8					
	Rolls and butter	81.8					
Liver, fried, with mashed potatoes	Liver and gravy	90.5	96.9	151.1	246.3	51.7	494.3
	Potatoes	129.8					
	Bread and butter	74.7					
Lobster	One serving	60.0	39.0	10.0	1.0	....	5.0
Macaroni, side order	One serving	119.8	19.2	14.4	92.2	....	125.8
Macaroni, baked, and cheese	Macaroni & cheese	212.1	49.9	46.9	266.4	40.5	363.2
	Bread and butter	42.9					
Macaroons	One	5.7	1.5	8.2	15.0	....	24.7
Mackerel, broiled salt, with mashed potatoes	Mackerel (edible)	100.8	156.6	339.4	272.7	44.1	768.7
	Potatoes	112.1					
	Bread and butter	98.9					
Maple flakes with milk	Maple flakes	31.3	45.9	84.5	134.9	....	265.3
	Milk	234.6					
Maple sugar	1 t.s.p.	7.0	0.0	0.0	25.0	....	25.0
Maple syrup	1 t.s.p.	9.0	0.0	0.0	25.0	....	25.0
Marmalade orange	One serving	14.1	0.2	0.0	49.5	....	49.7
Meat cakes, German with French fried potatoes	Meat cakes	123.5	93.8	398.0	361.6	27.2	853.4
	Potatoes	112.8					
	Bread and butter	67.8					
Meat cakes, German, with Lyonnaise potatoes	Meat cakes	156.3	125.8	344.5	268.9	....	739.2
	Potatoes	103.2					
	Bread	54.7					
Milk, one glass	One serving	453.6	56.7	156.9	76.9	....	290.5
Milk, condensed, sweetened	One serving	30.0	10.0	23.0	67.0	....	100.0

FOOD TABLE—*Continued*

Name of Food	Constituents: Food	Constituents: Gm.	Calories in Sample: Protein Nutritional	Calories in Sample: Fat	Calories in Sample: Carbohydrate	Nutritional Calories from Bread and Butter	Nutritional Calories per Portion
						%	
Milk, condensed, unsweetened	One serving	30.0	12.0	25.0	13.0	....	50.0
Milk, skimmed	One glass	190.0	25.0	5.0	37.0	....	67.0
Milk, butter	One glass	154.0	21.0	57.0	32.0	....	110.0
Muffins, corn	One serving	101.3	25.8	81.2	235.2	....	342.2
Muffins, hot corn	One serving	103.5	34.2	96.4	197.5	....	328.1
Mushrooms	Side dish	21.1	3.1	0.8	6.1	....	10.0
Napoleon	One serving	113.1	20.7	204.4	228.5	....	453.6
Nuts, almonds	One	1.4	1.4	7.0	1.0	....	9.4
Nuts, Brazil	One	3 5	2.3	23.0	1.5	....	26.8
Nuts, butter	One	1.0	2.7	20.0	0.9	....	23.8
Nuts, chestnut	One	1.0	0.3	4.5	1.6	....	6.4
Nuts, cocoanut	One serving	16.0	4.0	77.0	19.0	....	100.0
Nuts, English walnut	One	1.2	3.2	16.2	1.8	....	21.2
Nuts, filberts	One	1.4	0.9	8.4	0.7	....	10.0
Nuts, hickory	One	1.0	2.7	14.0	1.1	....	17.8
Nuts, peanut	One	0.8	0.9	2.5	0.7	....	4.1
Nuts, pecan	One	1.6	0.8	11.0	0.9	....	12.7
Nuts, pine	One	0.2	0.3	0.9	0.05	....	1.25
Oatmeal, fresh cooked, with cream	Oatmeal	195.9	33.8	212.7	136.5	....	383.0
	Cream	95.8					
Oleomargarine	1 t.s.p.	13.6	0.0	110.2	0.0	....	110.2
Olives, green	One (average)	5.3	0.1	12.0	2.0	....	14.1
Olives, ripe	One (average)	5.3	0.3	13.0	1.0	....	14.3
Omelet, chicken	Omelet	132.4	101.6	240.8	111.7	32.1	454.1
	Bread and butter	42.5					
Omelet, ham	Omelet	116.7	105.3	263.9	293.2	35.5	662.4
	Potatoes	68.4					
	Bread and butter	68.6					
Omelet, macaroni, with tomato sauce	Omelet	249.6	104.6	244.8	246.2	38.5	595.6
	Bread and butter	66.9					
Omelet, onion	Omelet	197.6	92.1	291.7	132.7	27.0	516.5
	Bread and butter	40.8					
Omelet, parsley	Omelet	103.0	72.2	214.1	174.6	53.1	460.9
	Bread and butter	71.5					
Omelet, plain (average 8 orders)	Omelet (average)	109.9	84.2	254.4	157.9	47.2	496.5
	Per cent variation from average	+5.8% / −8.0%	.... /	+25.7% / −17.6%	+40.3% / −35.4%		
	Bread and butter (average)	68.5					
	Per cent variation from average	+52.1% / −46.6%					
Omelet, Spanish, with French fried potatoes	Omelet	182.7	96.8	304.3	258.6	39.8	659.7
	Potatoes	59.0					
	Bread and butter	76.9					
Omelet, tomato	Omelet	178.9	104.5	313.5	279.4	55.3	697.4
	Rolls and butter	112.6					
Omelet, tomato, with potatoes	Omelet	170.5	59.8	205.2	344.7	42.9	609.7
	Potatoes	78.5					
	Bread and butter	76.5					
Onions, boiled	Side dish	140.0	6.0	20.0	24.0	....	50.0
Onions, creamed	One serving	168.0	8.0	36.0	47.0	....	91.0
Onions, scalloped	One serving	168.0	16.0	52.0	32.00	....	100.0
Oyster fry, large (average 2 orders)	Oysters (average)	191.8	90.0	364.8	354.2	35.1	809.0
	Per cent variation from average	+5.2% / −5.2%	.... /	+0.3% / −0.3%	+3.5% / −3.5%		
	Bread and butter (average)	82.9					
	Per cent variation from average	+10.4% / −10.4%					

FOOD TABLE—*Continued*

Name of Food	Constituents		Calories in Sample			Nutritional Calories from Bread and Butter	Nutritional Calories per Portion
	Food	Gm.	Protein Nutritional	Fat	Carbohydrate		
						%	
Oyster fry, plain, with bacon......	Oyster fry.......	196.1	116.5	469.4	444.6	32.0	1030.5
	Bacon...........	17.3					
	Bread and butter.	96.3					
Oyster fry, small.................	Oyster fry.......	167.9	84.5	218.6	393.5	36.6	696.6
	Bread and butter.	74.4					
Oyster pie.......................	One serving......	298.2	74.4	265.1	321.6	....	661.1
Oysters, raw.....................	One serving......	98.6	23.0	11.9	21.0	....	55.9
Parsnip, cream...................	One serving......	84.0	3.0	6.0	41.0	....	50.0
Parsnip, browned.................	One serving......	84.0	5.0	13.0	28.0	....	46.0
Peaches..........................	One.............	13.6	4.0	2.0	94.0	....	100.0
Peaches, sauce...................	One serving......	136.0	4.0	2.0	94.0	....	100.0
Peaches, juice...................	One glass........	177.4	0.0	0.0	0.0	90.0	90.0
Pears, large.....................	One.............	173.0	4.0	7.0	89.0	....	100.0
Pears, sauce.....................	One serving......	124.3	3.3	4.3	102.3	....	109.9
Pickles, cucumber................	One serving......	29.0	0.8	1.1	4.1	....	6.0
Pickles, mixed...................	One serving......	41.0	1.8	1.5	6.7	....	10.0
Pie, apple.......................	One serving......	137.5	15.0	101.2	221.0	....	337.2
Pie, blackberry..................	One serving......	154.2	14.9	94.9	246.0	....	355.8
Pie, cherry (average 2 orders)......	One serving......	170.3	16.7	91.5	274.8	....	383.0
	Per cent variation from average ...	+12.6% −12.6%	....	+36.7% −36.7%	+3.2% −3.2%		
Pie, cocoanut....................	One serving......	174.3	42.9	183.7	146.3	....	372.9
Pie, huckleberry.................	One serving......	159.6	11.4	81.9	266.1	....	359.4
Pie, lemon.......................	One serving......	146.1	13.1	96.3	170.3	....	279.7
Pie, mince.......................	One serving......	177.4	32.9	97.2	258.0	....	388.1
Pie, peach.......................	One serving......	169.6	11.8	93.9	258.0	....	363.7
Pie, pineapple...................	One serving......	161.5	14.4	113.7	219.3	....	347.4
Pie, pumpkin.....................	One serving......	170.9	29.2	79.1	187.8	....	296.6
Pie, rhubarb.....................	One serving......	116.2	11.4	75.8	199.6	....	286.8
Pie, strawberry..................	One serving......	149.5	16.8	86.0	273.2	....	376.0
Pineapple, sliced (average 2 orders).	Pineapple (av.)...	124.2	2.9	......	32.4	....	35.3
	Per cent variation from average....	+0.02% −0.02%					
Pork and beans, Boston............	Pork............	62.2	97.0	445.4	287.5	27.1	829.9
	Beans...........	166.1					
	Bread and butter.	65.7					
Pork and beans, New York (average 2 orders)	Pork (average)...	23.6	89.7	178.0	328.2	38.5	595.9
	Per cent variation from average....	+3.8% −3.8%	....	+14.3% −14.3%	+17.2% −17.2%		
	Beans (average)..	161.2					
	Per cent variation from average....	+3.4% −3.4%					
	Bread and butter (average).......	67.1					
	Per cent variation from average....	+2.9% −2.9%					
Potatoes, baked..................	(Average) One....	86.0	11.0	1.0	88.0	....	100.0
Potatoes, boiled.................	One small........	51.0	5.5	0.51	44.0	....	50.0
Potatoes, browned................	Large serving.....	98.0	12.0	6.0	112.0	....	130.0
Potatoes, French fried............	One serving......	131.7	22.8	96.3	201.7	....	220.8
Potatoes, mashed, with cream......	One serving......	89.0	10.0	25.0	65.0	....	100.0
Potatoes, sweet..................	One (average)....	98.0	12.0	18.0	170.0	....	200.0
Prunes...........................	One serving......	108.0	4.0	10.8	96.0	....	110.8
Pudding, bread, with vanilla sauce..	One serving......	201.8	34.2	37.4	226.8	....	298.4
Pudding, bread, custard...........	One serving......	203.9	40.8	48.9	265.7	....	355.4
Pudding, cabinet, with vanilla sauce (average 2 orders)	One serving (av.).	217.8	44.2	77.1	278.2	....	399.5
	Per cent variation from average....	+7.9% −11.0%	....	+7.9% −7.9%	+27.1% −27.1%		
Pudding, Indian, with maple sauce..	One serving......	167.9	24.9	58.5	143.8	....	227.2

FOOD TABLE—*Continued*

Name of Food	Constituents: Food	Constituents: Gm.	Calories in Sample: Protein Nutritional	Calories in Sample: Fat	Calories in Sample: Carbohydrate	Nutritional Calories from Bread and Butter	Nutritional Calories per Portion
						%	
Pudding, New England, with vanilla sauce	One serving	244.5	29.4	25.6	275.7	....	330.7
Pudding, rice, cold	One serving	227.7	31.3	47.4	184.4	....	263.1
Pudding, tapioca apple	One serving	224.5	21.1	21.4	174.7	....	217.2
Pudding, tapioca creamed	One serving	64.8	21.0	24.1	144.5	....	189.6
Radishes	One serving	24.0	0.9	0.1	3.6	....	4.6
Rhubarb, stewed	One serving	118.3	2.9	1.2	89.8	....	93.9
Rice, boiled, side order	One serving	161.6	12.2	1.3	117.3	....	130.8
Rice croquette with bacon (average 2 orders)	Rice croquette (average)	97.2	57.0	210.5	321.2	43.4	588.7
	Per cent variation from average	+17.5% −17.5%	....	+26.1% −26.1%	+5.5% −5.5%		
	Bacon (average)	4.9					
	Per cent variation from average	+3.1% −3.1%					
	Potatoes and sauce (average)	132.4					
	Per cent variation from average	+13.5% −13.5%					
	Bread and butter (average)	74.7					
	Per cent variation from average	+1.2% −1.2%					
Rice, flake	One dish	27.0	8.0	1.0	91.0	....	100.0
Rice, hot, with butter	One serving	188.3	19.7	79.8	205.7	....	305.2
Rice, hot, with cream	Rice, sugar, cream	338.4	34.8	258.4	226.9	....	520.1
Rice, hot, with milk	One serving	298.7	38.3	19.2	221.6	....	279.1
Rice, hot, with poached egg	Rice	153.1	57.7	118.8	253.3	49.8	429.8
	Poached egg	48.1					
	Bread and butter	62.5					
Roast, Vienna, with French fried potatoes	Roast	181.4	131.8	294.9	408.0	29.7	834.7
	Potatoes	71.4					
	Bread and butter	72.6					
Roast, Vienna, with spaghetti and potatoes	Vienna roast	103.9	103.2	255.6	350.1	34.0	708.9
	Spaghetti	69.4					
	Mashed potatoes	98.8					
	Buttered bread	70.5					
	Butter	10.7					
Roast, Vienna, with stewed tomatoes	Roast and tomatoes	136.1	74.3	247.9	201.9	31.3	524.1
	Bread and butter	47.8					
Rolls, Vienna	One	35.0	12.0	7.0	81.0	....	100.0
Salad, crab meat	Crab meat	114.0	101.2	131.4	165.4	68.1	398.0
	Lettuce	34.5					
	Boiled egg	13.7					
	Bread and butter	79.1					
Salad, egg	Eggs	117.6	86.0	196.0	182.0	54.9	464.0
	Lettuce	31.7					
	Bread and butter	74.5					
Salad, potato	Potatoes, etc	227.6	36.5	157.8	239.6	38.4	433.9
	Lettuce	18.3					
	Bread and butter	48.7					
Salad, tuna fish	Salad	166.0	94.1	282.8	177.5	43.0	554.4
	Bread and butter	69.8					
Sandwich, American cheese	One serving	63.7	35.7	103.1	91.4	....	230.2
Sandwich, chicken, sliced	One serving	50.0	27.8	38.4	90.0	....	156.2
Sandwich, chicken salad	One serving	92.0	34.6	111.4	123.3	....	269.3
Sandwich, club	Toast	73.3	79.9	179.1	148.2	....	407.2
	Lettuce	10.8					

FOOD TABLE—*Continued*

Name of Food	Constituents: Food	Constituents: Gm	Calories in Sample: Protein Nutritional	Calories in Sample: Fat	Calories in Sample: Carbohydrate	Nutritional Calories from Bread and Butter	Nutritional Calories per Portion
						%	
Sandwich, club	Chicken and bacon	42.4					
Sandwich, corned beef (average 18 orders)	Corned beef (av)	17.5	39.2	47.9	98.7	79.1	186.0
	Per cent variation from average	+44.5% / −50.9%	.... /	+80.1% / −82.9%	+27.2% / −21.4%		
	Bread and butter (average)	43.0					
	Per cent variation from average	+17.4% / −26.1%					
Sandwich, cream cheese, walnut	One serving	58.3	20.9	77.7	102.9	....	201.5
Sandwich, fried egg	Egg	38.8	43.0	108.4	107.8	64.7	259.2
	Bread and butter	49.0					
Sandwich, fish cake	Fish cake	56.9	44.9	48.8	141.8	....	235.5
	Bread (no butter)	47.5					
Sandwich, ham (average 18 orders)	Ham (average)	18.3	35.0	68.7	94.7	73.2	198.3
	Per cent variation from average	+47.0% / −50.8%	.... /	+49.0% / −34.8%	+22.5% / −16.1%		
	Bread and butter (average)	42.4					
	Per cent variation from average	+19.6% / −19.6%					
Sandwich, ham, with roll	Ham	13.9	30.5	113.3	119.0	....	261.8
	Roll	52.4					
Sandwich, minced chicken	Chicken	20.6	37.7	89.5	93.1	73.0	220.3
	Bread and butter	47.0					
Sandwich, minced chicken, with lettuce	One serving	78.6	24.9	49.8	97.8	....	172.5
Sandwich, minced ham	Ham	18.3	35.2	150.6	91.5	63.8	277.3
	Bread and butter	51.7					
Sandwich, minced ham, with olives	One serving	61.6	32.1	99.2	75.5	....	206.8
Sandwich, minced tongue, with tea biscuits	One serving	76.2	35.5	62.9	127.2	....	225.6
Sandwich, oyster	Oyster	61.4	36.4	129.0	142.2	46.3	307.6
	Bread	41.4					
Sandwich, Pimento, olive, cheese	Cheese, etc	6.1	18.4	52.0	81.9	87.0	152.3
	Bread and butter	38.7					
Sandwich, roast beef, hot	Beef	37.4	49.8	82.2	112.4	....	244.4
	Bread and gravy	62.3					
Sandwich, roast beef, with roll	Roast beef	50.3	71.6	156.8	129.4	....	357.8
	Roll	54.7					
Sandwich, sardine	One serving	59.5	26.6	91.3	89.5	....	207.4
Sandwich, Swiss cheese	Swiss cheese	20.8	37.0	120.5	86.5	59.6	244.0
	Bread and butter	42.5					
Sandwich, tomato	Tomatoes	16.0	16.4	25.1	92.1	96.5	133.6
	Lettuce	5.1					
	Bread and butter	43.4					
Sausage, bologna	One serving	56.7	42.4	79.8	0.7	....	122.9
Sausage, country	One serving	81.0	41.4	187.7	......	....	227.7
Sausage, country, and French fried potatoes	Sausage	53.8	51.4	310.3	139.9	....	501.6
	Potatoes and gravy	106.5					
Sausage, frankfurters	One serving	56.7	44.5	38.5	3.5	....	131.3
Shad, baked, and dressing	Shad (edible)	149.7	128.2	223.0	279.4	....	630.6
	Potatoes and dressing	130.6					
	Bread	65.5					
Shortcake, strawberry	One serving	122.9	19.8	100.4	155.1	....	275.3
Shredded wheat and cream	Shredded wheat	60.6	40.5	227.8	210.3	....	478.6
	Cream	102.0					
Shredded wheat and milk	Shredded wheat	61.4	58.3	83.0	240.3	....	381.6
	Milk	220.1					

FOOD TABLE—*Continued*

Name of Food	Constituents: Food	Constituents: Gm.	Calories in Sample: Protein Nutritional	Calories in Sample: Fat	Calories in Sample: Carbohydrate	Nutritional Calories from Bread and Butter	Nutritional Calories per Portion
						%	
Soup, bean, with croutons	One serving	300.5	30.5	44.8	93.5	....	168.8
Soup, chicken	Chicken soup	369.6	50.7	87.4	163.1	49.5	301.2
	Bread and butter	43.6					
Soup, cream of celery	One serving	90.0	8.0	23.5	18.5	....	50.0
Soup, consomme	One serving	83.0	8.5	0.0	1.5	....	10.0
Soup, green split pea	Soup	220.3	33.0	45.3	149.9	59.4	228.2
	Bread and butter	39.7					
Soup, lentil	One serving	90.0	28.6	67.5	57.6	....	153.7
Soup, oxtail	One serving	90.0	24.0	16.2	24.0	....	64.2
Soup, tomato	One serving	90.0	15.6	32.4	44.4	....	92.4
Soup, tomato, with rice	One serving	222.0	11.3	9.7	52.1	....	73.1
Soup, vegetable	Soup	227.9	25.2	37.6	133.4	79.6	196.2
	Bread and butter	45.6					
Spaghetti and cheese	One serving	212.9	30.5	21.4	124.0	....	175.9
Spaghetti, baked with cheese	One serving	168.9	26.3	14.2	115.6	....	156.1
Spinach	One serving	87.0	7.5	33.0	9.5	....	50.0
Squash, baked	One serving	102.0	6.0	5.0	39.3	....	50.3
Steak, hamburger	Steak	94.0	106.2	288.8	287.1	29.9	682.1
	Potatoes	131.0					
	Bread and butter	59.6					
Steak, hamburger, with Spanish sauce	Steak	109.2	131.6	225.2	272.8	33.7	629.6
	Spanish sauce	85.4					
	French fried potatoes	65.7					
	Bread and butter	61.9					
Steak, sirloin	Steak	262.7	285.6	685.9	309.3	20.1	1280.8
	Potatoes	96.5					
	Water cress	5.4					
	Bread and butter	75.1					
Steak, sirloin, with onions	Steak	182.9	265.2	578.4	366.2	20.1	1209.8
	Onions	63.4					
	Potatoes	95.7					
	Bread and butter	71.2					
Steak, small (average 2 orders)	Steak (average)	146.5	170.5	583.5	211.8	28.3	965.8
	Per cent variation	+1.0%	....	+22.8%	+8.0%		
	from average	−1.0%	....	−22.8%	−8.0%		
	Potatoes (average)	70.9					
	Per cent variation	+21.2%					
	from average	−21.2%					
	Bread (average)	70.2					
	Per cent variation	+2.8%					
	from average	−2.8%					
	Butter (average)	9.6					
	Per cent variation	+47.0%					
	from average	−47.0%					
Steak, small, with onions	Steak	134.5	197.5	447.6	301.4	25.8	946.5
	Onions	57.7					
	Potatoes	96.8					
	Bread and butter	71.2					
Steak, tenderloin	Steak	213.3	251.1	543.7	374.5	19.8	1169.3
	Potatoes	133.8					
	Bread and butter	67.6					
Steak, tenderloin, with onions	Steak	222.7	264.5	632.6	462.0	24.5	1359.1
	Onions	46.2					
	Potatoes	123.7					
	Bread and butter	97.4					
Stew, beef (average 9 orders)	Stew (average)	408.3	106.8	234.1	258.5	35.3	599.4
	Per cent variation	+20.8%	....	+37.3%	+29.4%		
	from average	−10.8%	....	−51.7%	−23.1%		

FOOD TABLE—*Continued*

Name of Food	Constituents: Food	Constituents: Gm.	Calories in Sample: Protein Nutritional	Calories in Sample: Fat	Calories in Sample: Carbohydrate	Nutritional Calories from Bread and Butter	Nutritional Calories per Portion
						%	
Stew, beef (average 9 orders)	Bread and butter (average)	61.8					
	Per cent variation from average	+25.4% −35.3%					
Stew, lamb (average 2 orders)	Stew (average)	355.9	105.4	234.7	240.7	39.6	580.8
	Per cent variation from average	+4.1% −4.1%	....	+17.8% −17.8%	+3.0% −3.0%		
	Bread and butter (average)	67.3					
	Per cent variation from average	+6.0% −6.0%					
Strawberries with cream	Strawberries	142.0	12.9	20.0	242.8	....	275.7
	Cream	91.1					
Strawberries with ice cream	One serving	212.1	13.9	64.5	116.7	....	195.1
Succotash	One serving	100.0	15.0	9.0	67.0	....	100.0
Sugar, granulated	1 t.s.p.	8.0	0.0	0.0	33.0	....	33.0
Sugar, loaf	One	16.0	0.0	0.0	33.0	....	33.0
Tart, strawberry	One serving	90.6	8.1	140.2	73.6	....	221.9
Toast, buttered	One serving	73.3	30.7	87.1	181.5	....	299.3
Toast, French, with maple cane syrup	Toast	111.6	63.4	388.4	265.0	....	716.8
	Butter	20.0					
	Syrup	40.0					
Toast, milk	One serving	229.0	47.2	99.5	174.6	....	316.8
Tomatoes, sliced	One serving	142.5	4.8	......	25.5	....	30.3
Tomatoes, sliced with lettuce	Tomatoes	79.8	5.9	......	43.9	....	49.8
	Lettuce	43.2					
Tomatoes, stewed	One serving	86.2	4.2	1.4	14.4	....	20.0
Tomatoes and lettuce with dressing	Tomatoes	117.3	8.9	......	44.9	....	53.8
	Lettuce	53.4					
	Dressing	11.6					
Tripe	One serving	86.0	43.0	10.0	2.0	....	55.0
Turkey	One serving	68.0	58.0	142.0	0.0	....	200.0
Turnip, mashed	One serving	113.0	3.0	29.0	13.0	....	45.0
Veal cutlet, breaded, with tomato sauce	Breaded veal	133.3	127.7	349.4	370.6	33.0	847.7
	Potatoes and gravy	152.7					
	Bread	61.8					
	Butter	20.0					
Veal pot pie with dumplings	Pie and dumplings	277.0	110.0	136.2	278.6	47.9	524.8
	Bread and butter	73.6					
Watermelon (2 orders)	Edible portion	1080.0	19.8	......	216.7	....	118.3
Weakfish, baked, with dressing	Fish and dressing	179.6	112.5	159.3	243.7	45.0	515.5
	Mashed potatoes	119.5					
	Bread and butter	68.7					
Whey	One glass	180.0	7.5	5.0	37.5	....	50.0
Zwiebach	One	23.0	9.0	21.0	70.0	....	100.0

FOOD VALUES OF CANDIES

Name	Calories per Pound	Name	Calories per Pound
Sugar Coated Jordan Almonds	2410	French Burnt Peanuts	2040
Caramels	1451	Fudge	1587
Chocolate Dipped Cream Caramels	2155	Gum Drops	1685
Chocolates—Cream Centers	2092	Hard Boiled Candies	1587
Chocolates—Nut Centers	2498	Jelly Beans	1708
Chocolate—Tablets, etc.	2860	Lozengers	1795
Cocoanut Bon Bons	1750	Marshmallows	1737
Cocoanut Caramels	1675	Stick Candy	1745
Cream Filberts	1913		

COOKING OF FOOD

Why Foods are Cooked.—Most foods are better when cooked, because:

1. Cooking sterilizes the food, killing molds, parasites, and bacteria. In the case of roast meat, the interior is seldom sterilized. Bread has been known to have lactic bacteria present in the center.

2. Cooking makes the food more palatable and thus aids digestion, as such food is well chewed.

3. Starchy foods containing cellulose (a fibrous material), such as vegetables, are more easily digested. Fruits such as bananas and green apples should be cooked because of the starch present. Cooking changes the starch to dextrine and glucose. Pineapples and some kinds of pears and roots need cooking because of the cellulose in them.

Paper, rags and wood contain large quantities of cellulose. Goats are able to digest cellulose and obtain real food, but the human being is not. Cellulose is used for the manufacture of paper.

With the exception of lettuce and tomatoes, nearly all vegetables should be cooked, because of the presence of starch and woody fibers. Celery contains little if any starch, although it is fibrous.

Over-Cooking.—Over-cooking is sometimes very bad for digestion. Cooking at high temperatures toughens some foods. Eggs are an example of this. Food should be cooked at a lower temperature than 212°, if possible. For this reason fireless cookers are far more efficient than ordinary stoves for cooking foods.

Steam cooking is used because steam penetrates more deeply than water, dissolving the extractives of meat and other foods.

Digestion and Enzymes.—**Enzymes** are substances found in the glands of the body. The enzymes bring about digestion by changing starch into sugars.

The digestion of carbohydrate foods starts in the mouth under the influence of an enzyme called **ptyalin.** Cold liquids and acids retard the digestion of carbohydrates. It is best not to drink water during the mastication of such foods. Acid foods would be far more preferable after a meal than before.

Proteids do not digest in the mouth at all but in the stomach

and the intestines. Too much protein food will produce indigestion and bacteria decomposition in the intestines. A fetid odor of the intestines is often due to over-eating of protein.

Digestion of Meat.—Meat should be carved across the grain in very thin slices so as to cut the fibers into as many sections as possible. Long fibers digest slowly. The more fat in meat the more slowly it digests. Raw meat would digest more easily than cooked meat, but it is too dense to masticate well.

Chewing of Food.—Food must be chewed so as to break up the particles as much as possible, allowing the digestive fluids to come in contact with all parts of the food material. If the food particles are too large, the digestive fluids reach only the outside, and a great deal of food is wasted because undigested.

Care of the Teeth.—The teeth are an important factor in digestion, and great care should be taken of them. Decay is caused by

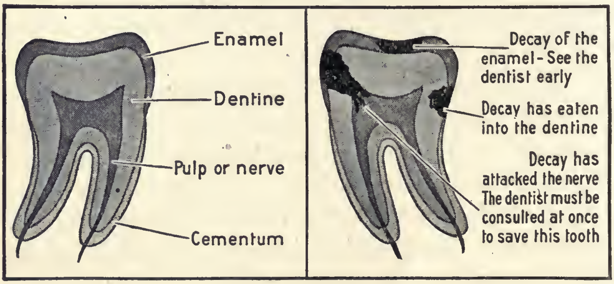


FIG. 145.—Why should the teeth be examined frequently? Why should the teeth be cleaned after every meal?

bacteria growing in the moist, warm food left between the teeth. If, after eating, the food is cleaned from the teeth with the aid of a brush and a good tooth powder, the danger of the presence of bacteria is removed.

One should avoid biting on threads, nuts, candy or any other hard material, for it is liable to break the enamel, and decay will set in, wherever the dentine is exposed. Decaying food between the teeth produces an acid which slowly eats away the enamel of the teeth.

Tartar, a dark-colored substance which is supposed to be caused by bacteria, should be removed by a dentist, for it causes the gums to shrink, and exposes the necks of the teeth below the enamel. People should regularly visit the dentist in order to preserve the teeth, for if cavities are small, they can be filled at a comparatively small cost. If a person does not have good teeth the stomach suffers, since the food is not properly prepared to be received by that organ.

Use of Fat in Cooking.—Fat encloses the food particles and prevents the digestive fluid from reaching the food. Fried foods, for this reason, are often indigestible. Butter, cream and olive oil are emulsifiable fats which do not interfere to any extent with digestion.

Frying with Fat.—Fat for frying is far above the temperature of boiling water. Fat for frying food should be very hot so as to form a crust on the outside of the food and prevent the fat from soaking in. Too much cold food placed in the fat at one time will cool the fat, which will soak into the food and surround the starch grains, preventing the digestive fluid from easily reaching the starch to change it into sugar.

If steak is placed in a cold frying pan with some fat, each individual fiber of the meat is covered with a layer of fat which prevents the food from digesting. Broiling, or cooking the steak in a hot frying pan, is the better way to prepare steak for food.

Function of Warm Soup.—A warm soup at the beginning of a meal stimulates the appetite and the secretions of the stomach.

Cooking of Vegetables.—Heat swells the starch granules, which burst, forcing apart the cellular structure in which the starch grains are located. This allows the digestive fluids to act on the starch. Vegetables are cooked to bring about this result.

Vegetables must be placed in hot water to retain their flavor, but if the flavor is to be extracted, as in the case of onions, the vegetables should be placed in cold water and slowly brought to boiling point.

Cooking of Meats.—Heat coagulates protein. If the juice of meats is to be kept inside, the meat should be heated very quickly. If the juice is to be extracted, heat the meat slowly, keeping the temperature below 185° F., which will prevent coagulation.

Sometimes meat is put into boiling water to coagulate the outside, and the temperature allowed to drop to about 185° F. This process of cooking, which is called **simmering,** makes the meat very tender if cooked for a long time.

Cooking of Eggs.—Eggs should be placed in cold water and brought to a boil. Since the protein (albumen) coagulates at a temperature of 158° F., if the egg is put into hot water the outer layer coagulates, leaving the inner part uncooked. If an egg is put into hot water it should not be allowed to boil.

PERIODS OF DIGESTION

LENGTH OF TIME REQUIRED FOR DIGESTION OF VARIOUS FOODS

	Hours.	Min.		Hours.	Min.
Rice	1	0	Mutton, boiled	3	0
Eggs, raw	1	0	Beef, roast	3	0
Apples	1	30	Bread, fresh	3	15
Trout, broiled	1	30	Carrots, boiled	3	15
Venison, broiled	1	35	Turnips, boiled	3	30
Sago, boiled	1	45	Potatoes, boiled	3	30
Milk, boiled	2	0	Butter	3	30
Bread, stale	2	0	Cheese	3	30
Milk, raw	2	15	Oysters, stewed	3	30
Turkey, boiled	2	25	Eggs, hard	3	30
Goose, roast	2	30	Pork, boiled	3	30
Lamb, broiled	2	30	Fowl, roast	4	0
Potatoes	2	30	Beef, fried	4	0
Beans, boiled	2	30	Cabbage	4	30
Parsnips, boiled	2	30	Wild fowl	4	30
Oysters, raw	2	55	Pork, roast	5	15
Eggs, boiled	3	0	Veal, roast	5	30

QUESTIONS

1. What is the necessity for cooking foods?
2. What is the effect of over-cooking food?
3. Why are fireless cookers efficient for cooking foods?
4. Why should not cold water be taken during the chewing of foods?

5. Why should food be well chewed?

6. Why is the carving of meat an important factor in digestion?

7. What are the two essentials of tooth powder or tooth paste for cleaning the teeth?

8. When are crullers very indigestible?

9. What is the value of warm soup before a meal?

10. Why should oatmeal be well cooked?

11. How should the cooking of onions and similar vegetables differ from that of beets?

12. How should beef be cooked to obtain beef extract?

13. What kinds of food would be bad to eat just before going to bed?

14. What foods digest easily? Slowly?

15. Why should a person eat for breakfast food which digests quickly?

16. Why is it necessary to eat foods which have different periods of digestion?

17. Why is the crust of bread sweet?

18. Why should invalids eat toast?

19. Why do thin pieces of potato become swollen when dropped into hot fat?

20. Why is the meat in a soup tasteless?

21. What part of this section do you consider of greatest value?

MILK

Source of Milk.—Milk is made from the blood of the cow by two large glands. The blood is red, but milk is never bloody unless the cow is sick. The glands are soft, spongy organs, containing a fine network of ducts, and lined with secreting cells which prepare the milk from the blood. Most of the milk is actually formed while the cow is being milked.

Milk contains all the food that is necessary for the growth and development of young animals. Some cows have produced from 10 to 15 times their own weight of milk in a year (over 20,000 pounds); but this is rare, as the average cow gives only about 2 to 4 times her own weight.

Composition of Milk.—Milk is composed of water, fat, casein, albumen, milk sugar, ash, and a few other substances in small quantities. The average cow's milk contains

Water	87.1 per cent		
Solids	12.9 per cent	Fat	3.9 per cent
		Casein	2.5 per cent
		Albumen	0.7 per cent
		Sugar	5.1 per cent
		Ash	0.7 per cent

Fat is found in the milk in the form of small globules. About 6000 of them placed side by side would be required to make an inch. Casein gives the milk the bluish white color and is the curd found in sour milk. This casein, after treatment with certain chemicals, is often used for the manufacture of knife handles, billiard balls, piano keys, combs, backs of hair brushes, and countless other articles. The skim milk is treated with sulphuric acid to obtain the casein.

Project 5.—Look up the uses of casein, and processes for manufacturing articles from it.

Adulterations of Milk.—Milk is adulterated by:

1. Addition of water.
2. Removal of cream.
3. Use of preservatives.

To tell whether the cream has been removed from the milk, and to determine the solids not fat, it is necessary to test for the amount of fat by the Babcock Test Method.

Babcock Test for the Per Cent of Fat in Milk.—Add strong sulphuric acid to milk to dissolve all the solids except the fat which is afterwards separated by means of a centrifugal machine.

Measure exactly 17.6 c.c. of the milk into a Babcock bottle by means of a milk pipette. Add exactly 17.5 c.c. of H_2SO_4, specific gravity 1.83, inclining the bottle so that the acid will run in slowly, washing all adhering milk from the neck.

Shake with a rotary motion so as thoroughly to mix the acid and milk. Avoid getting curds into the neck of the bottle.

If the work has been done properly the mixture will be a dark color and very hot. Place directly in a centrifuge, arranging the bottle so that the rotating head will balance properly. If the machine vibrates badly the balance is not correct and should be adjusted.

Centrifuge for five minutes; then set the bottle in a pan of hot water and add sufficient hot water to bring the fat up to the neck of the bottle.

Centrifuge for two minutes and add sufficient hot water to bring the fat opposite the graduated scale.

Centrifuge for one minute, and take the reading from the scale in tenths of 1 per cent.

A pair of small dividers is useful for determining the length of the fat column. This determined, place one leg of the dividers upon zero and take the reading from the opposite leg. It is customary to take the distance from the bottom of the fat column to the top as the true length.

The fat in milk varies from 2.2 per cent to 9.0 per cent. The United States standard is 3.25 per cent. What is the standard in your State?

Mineral Matter in Milk. Milk contains calcium, iron, magnesium, potassium, sodium, sulphur and phosphorus. All these minerals are essential to the human body. This material is usually spoken of as *solids not fat.* The average amount of solids not fat in milk should be about 8.2 per cent.

The old practice of watering milk has largely disappeared, since the Babcock test so easily determines whether the grade of milk is good or poor.

An instrument called a **lactometer** which looks something like a floating thermometer is used to detect the addition of water. The lactometer determines the specific gravity of the milk; that is, the number of times heavier the milk is than water. The specific gravity of milk varies from 1.029 to 1.035. If water has been added, the specific gravity reads too low. If the fat has been removed, the specific gravity reads too high. If, however, the adulterator removed some of the fat and added the correct amount of water, the lactometer will show a specific gravity of normal milk. The Babcock test will readily show the condition of the milk.

The following formula is often used to determine the per cent of solids not fat. Remember, normal milk has an average of 8.2 per cent solids not fat. Test some of the milk you are using at home.

Formula for Finding the Total Amount of Solids in Milk.

$\frac{G}{4}+\frac{F}{5}+.14=$ S.N.F. (Solids not fat.)

Add 4 points to the lactometer reading for every degree above 60°.

For example, suppose the $\left\{\begin{array}{l}\text{Lactometer reads } 104°.\\ \text{Thermometer reads } 62°.\end{array}\right.$

$104°+8°=112°$.

$G=$ specific gravity.

$F=$ butter fat.

Multiply by .29, the corrected reading of the lactometer.

$.29\times 112°=32.48$ specific gravity.

The real specific gravity is 1.03248.

Suppose the amount of fat in milk was 3.3 per cent.

Then

$$\frac{G}{4}+\frac{F}{5}+.14=\text{S.N.F.}\quad \frac{32.48}{4}+\frac{3.3}{5}+.14=8.92.$$

Leach's Casein Test for Formaldehyde.—To 2 tablespoonfuls of pure milk add an equal volume of hydrochloric acid, containing about 1 per cent of Fe_2Cl_6. Place in a basin of water so as not to burn the milk, and heat slowly, stirring or shaking the contents constantly to break up the curd. When nearly, but not quite, at boiling point, remove the heat. If a purple color shows anywhere on the sides of the test tube or dish, formaldehyde was used to preserve the milk.

Milk does not sour if preserved with formaldehyde; it rots. Formaldehyde is very seldom found in milk. Occasionally a poor grade of old milk will be found to have been preserved with it.

Detection of Boron Compounds.—Place 5 c.c. of pure milk in a watch glass and acidulate slightly with 10 per cent HCl. Add five drops of turmeric tincture, and evaporate to dryness over a water bath. A red color indicates boric acid or other boron compounds.

Detection of Bicarbonate of Soda.—The ash of pure milk shows no effervescence with HCl. Burn 10 c.c. of milk to a white ash in a porcelain or quartz

crucible over a low flame. Treat the ash with a drop of dilute HCl. An effervescence indicates bicarbonate of soda.

Detection of Hydrogen Peroxide in Milk.—Add 2 or 3 drops of a 2 per cent aqueous solution of paraphenylenediamine hydrochloride to a small amount of milk. A blue color indicates the presence of hydrogen peroxide which was added to keep the milk from souring.

Detection of Coal Tar Dyes in Milk.—Coloring matter is sometimes added to milk to give it a rich, creamy appearance. To 2 teaspoonfuls of milk add an equal volume of hydrochloric acid and mix thoroughly. A pink coloration indicates the presence of Azo Orange, a coal tar dye. Annatto is also used to color milk.

Test for Foreign Matter in Milk.—Sometimes milk is contaminated by dirt, hair and other matter which is dangerous to the purchaser. A simple test may be made by pouring a bottle of milk through absorbent cotton placed in a glass funnel. All foreign matter such as dirt, manure, hair, etc., will be left on the absorbent cotton.

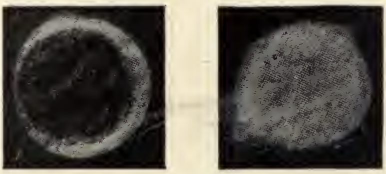


FIG. 146.—Two cotton discs, one of which shows large quantities of dirt, manure, and other foreign matter. The other shows that the milk is fairly free from foreign material. The milk was strained through the discs as explained. Test your milk at home.

Disease-producing germs or bacteria are often introduced through foreign matter which gets into the milk. Typhoid fever, sore throat, scarlet fever and tuberculosis may be traced to unclean milk.

Pasteurization.—Milk is often heated for twenty minutes at a temperature between 140° and 180° to kill most of the active bacteria. Heating at this temperature does not destroy the taste of the milk. This process was originated by the famous French chemist Pasteur.

Number of Bacteria Allowed in Milk.—Some parts of the country allow 50,000 bacteria per cubic centimeter of milk. Milk which has

REGULATIONS GOVERNING THE GRADES AND DESIGNATION OF MILK AND

The following classifications apply to milk and cream. The regulations regarding

Grades of Milk or Cream Which May Be Sold.	Definition.	Tuberculin Test and Physical Condition.	Bacterial Contents.
Grade A Milk or Cream (Raw)	Grade A milk or cream (raw) is milk or cream produced and handled in accordance with the minimum requirements, rules and regulations as herein set forth.	1. Only such cows shall be admitted to the herd as have not reacted to a diagnostic injection of tuberculin, and are in good physical condition. 2. All cows shall be tested annually with tuberculin, and all reacting animals shall be excluded from the herd.	Grade A milk (raw) shall not contain more than 60,000 bacteria per c.c., and cream more than 300,000 bacteria per c.c. when delivered to the consumer or at any time prior to such delivery.
Milk or Cream (Pasteurized)	Grade A milk or cream (pasteurized) is milk or cream handled and sold by dealers holding permits therefor from the Board of Health, and produced and handled in accordance with the requirements, rules and regulations as herein set forth.	No tuberculin test required but cows must be healthy as disclosed by physical examination made annually.	Grade A milk (pasteurized) shall not contain more than 30.-000 bacteria per c.c. and cream (pasteurized) more than 150,000 bacteria per c.c. when delivered to the consumer or at any time after pasteurization and prior to such delivery. No milk supply averaging more than 200,000 bacteria per c.c. shall be pasteurized for sale under this designation.
Grade B Milk or Cream (Pasteurized)	Grade B milk or cream (pasteurized) is milk or cream produced and handled in accordance with the minimum requirements, rules and regulations herein set forth, and which has been pasteurized in accordance with the requirements and rules and regulations of the Department of Health for pasteurization.	No tuberculin test required but cows must be healthy as disclosed by physical examination made annually.	No milk under this grade shall contain more than 100,000 bacteria per c.c. and no cream shall contain more than 500,000 bacteria per c.c. when delivered to the consumer or at any time after pasteurization and prior to such delivery. No milk supply averaging more than 1,500,000 bacteria per c.c. shall be pasteurized in this city for sale under this designation. No milk supply averaging more than 300,000 bacteria per c.c. shall be pasteurized outside of this city for sale under this designation.
Grade C Milk or Cream (Pasteurized) (For cooking and manufacturing purposes only.)	Grade C milk or cream is milk or cream not conforming to the requirements of any of the subdivisions of Grade A or Grade B, and which has been pasteurized according to the requirements and rules and regulations of the Board of Health or boiled for at least two (2) minutes.	No tuberculin test required but cows must be healthy as disclosed by physical examination made annually.	No milk of this grade shall contain more than 300,000 bacteria per c.c. and no cream of this grade shall contain more than 1,500,000 bacteria per c.c. after pasteurization.

NOTE—Sour milk, buttermilk, sour cream, kumyss, matzoon, zoolac and similar and shall be pasteurized before being put through the process of souring. Sour cream shall

No other words than those designated herein shall appear on the label of any container authorized under the State laws.

CREAM WHICH MAY BE SOLD IN SOME PARTS OF THE COUNTRY.

bacterial content and time of delivery shall not apply to sour cream.

Time of Delivery.	Bottling.	Labeling.	Pasteurization.
Shall be delivered within 36 hours after production.	Unless otherwise specified in the permit this milk or cream shall be delivered to the consumer only in bottles.	Outer caps of bottles shall be white and shall contain the words Grade A, Raw, in black letters in large type, and shall state the name and address of the dealer.	
Shall be delivered within 36 hours after pasteurization.	Unless otherwise specified in the permit this milk or cream shall be delivered to the consumer only in bottles.	Outer caps of bottles shall be white and shall contain the words Grade A in black letters in large type, date and hours between which pasteurization was completed; place where pasteurization was performed; name of the person, firm or corporation offering for sale, selling or delivering same.	Only such milk or cream shall be regarded as pasteurized as has been subjected to a temperature averaging 145° Fahr. for not less than 30 minutes.
Milk shall be delivered within 36 hours and cream within 48 hours after pasteurization.	May be delivered in cans or bottles.	Outer caps of bottles containing milk and tags affixed to cans containing milk or cream shall be white and marked "Grade B" in bright green letters in large type, date pasteurization was completed, place where pasteurization was performed, name of the person, firm or corporation offering for sale, selling or delivering same. Bottles containing cream shall be labeled with caps marked "Grade B" in bright green letters, in large type and shall give the place and date of bottling and shall give the name of person, firm or corporation offering for sale, selling or delivering same.	Only such milk or cream shall be regarded as pasteurized as has been subjected to a temperature averaging 145° Fahr. for not less than 30 minutes.
Shall be delivered within 48 hours after pasteurization.	May be delivered in cans only.	Tags affixed to cans shall be white and shall be marked in red with the words "Grade C" in large type and "for cooking" in plainly visible type, and cans shall have properly sealed metal collars, painted red on necks.	Only such milk or cream shall be regarded as pasteurized as has been subjected to a temperature averaging 145° Fahr. for not less than 30 minutes.

products shall not be made from any milk of a less grade than that designated for "Grade B,"
not contain a less percentage of fats than that designated for cream.
containing milk or cream or milk or cream products except the word "certified" when

a greater number of bacteria than this is unfit for food, and should be looked upon with suspicion. Of course it would be impossible to count the bacteria in 1 cubic centimeter of milk, but an estimate is made in a very simple way. One cubic centimeter of milk is put into 999 cubic centimeters of sterilized water, making a total of 1000 cubic centimeters of diluted milk. This is thoroughly agitated and one drop of the mixture is placed on sterilized gelatin beef broth. In a few days little spots or molds appear. These are little colonies of bacteria, each one representing the place where one bacterium from the milk started a whole colony. If the colonies are counted,

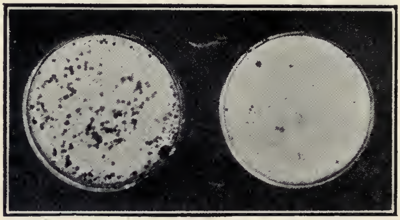


PLATE NO. 1— DIRTY MILK. PLATE NO. 2.— CLEAN MILK.

FIG. 147.—Bacterial Plates of Milk. Bacteria are tiny plants which grow in proper soil. The round glass dishes contain a beef jelly in which is mixed a little milk. The microscopic bacteria in two days develop colonies indicated by the spots. The number of spots indicate the number of bacteria originally in the milk. One cubic centimeter of milk is diluted with 99 c.c. of water, and higher dilutions are made when necessary before planting the bacteria in these glass plates. The total number per c.c. is obtained by multiplying the number of spots by the dilution.

and multiplied by the number of times the milk was diluted, the number of bacteria in each drop of milk is easily estimated. Bacteria growing in milk cause the milk to sour, for they change the milk sugar to an acid. The common notion that thunder-storms cause milk to sour is a fallacy.

QUESTIONS

1. Why is milk one of the essential foods?
2. Why should milk be well cared for?
3. What precautions should always be taken regarding the handling of milk?

4. What happens when a bottle of milk freezes?

5. Why should milk bottles full of milk never be left on a door step to freeze in the winter? (Suggestion—stray dog or cat.)

6. Why should a small box with a cover be placed outside the house so that the milkman can place the milk in it?

7. Why is milk sometimes adulterated?

8. How may we determine whether milk has sufficient fat?

9. Some cows, as the Durham, do not give milk rich enough in fat to meet the standard requirement of butter fat.

What cows must the farmer keep in his herd to bring the butter fat of the milk up to standard?

10. Why is it essential to know the total amount of solid matter in milk?

11. Why is formaldehyde objectionable in milk?

12. Why is any preservative objectionable in milk?

13. Why do cities and towns often require that milk be sterilized?

14. **Project.**—Find out the requirements of the Board of Health in your town or city regarding milk.

USES OF CARBON DIOXIDE IN COOKING

Use of Ammonium Carbonate.—Sometimes ammonium carbonate, as a fine powder, or as a solution, is mixed with flour in order to form a gas for raising dough during the process of baking. The ammonium carbonate changes into ammonium gas, water, and carbon dioxide. Bakers have added ammonium carbonate and yeast to bread in order to make the bread light and the loaf very large. Ammonium carbonate will overcome the sourness of bread, but bread made this way is usually dry and tasteless.

Use of Baking Soda.—Another way of raising bread is through the use of sodium bicarbonate (baking soda). This salt, when heated, gives off carbon dioxide and water, but the product left in the bread is very unwholesome.

Use of Hydrochloric Acid and Baking Soda.—We have learned that an acid and a carbonate produce carbon dioxide. This method of producing carbon dioxide has been used for raising bread. Hydrochloric acid and baking soda produce carbon dioxide and common

salt, but bread made by this process has not been very satisfactory because of its flavor.

Baking Soda and Molasses.—Molasses contains some free acid which acts upon baking soda and produces carbon dioxide. Vinegar is sometimes added when the acid in the molasses is not sufficient. Gingerbread is made by this process.

Sour Milk Bread.—Sour milk contains an acid known as lactic acid. When sour milk and baking soda are used to produce carbon dioxide for raising bread, sodium lactate, a harmless salt, is left in the bread. An excess of baking soda causes the bread to become yellow and unwholesome, since washing soda is formed in the product.

Baking Soda and Cream of Tartar.—Cream of tartar (tartaric acid) is obtained from Argol, a product found on the inside of wine barrels. The tartaric acid has crystallized from the grape wine. When cream of tartar and soda are used for making bread, carbon dioxide is formed, and Rochelle salts is left in the bread. A great deal has been said about the unwholesomeness of this residue, but, although a loaf of bread will have more of this salt than a seidlitz powder, the amount of bread eaten at one meal is so small that the effect on the system may be disregarded. Rochelle salts has a slightly laxative effect. A good baking powder may be made by mixing two pounds of baking soda with four pounds of cream of tartar and a little less than two pounds of starch. The starch and soda should be mixed first.

Phosphate Baking Powder.—Another type of baking powder is made from calcium acid phosphate and baking soda. This baking powder leaves calcium phosphate and sodium phosphate in the bread.

Burnt Alum Baking Powder.—A great many objections have been made to the use of alum baking powder because this powder leaves in the bread aluminum hydroxide, which is not soluble in the gastric juices of the stomach. Alum has an astringent action on the system, producing a tendency to constipation. As ammonium alum has an irritating effect on animal tissue it is considered very objectionable.

Burnt alum baking powder leaves in the bread aluminum hydroxide, sodium sulphate (Glauber's salt), and potassium sulphate.

Sodium aluminum sulphate is sometimes used in the place of burnt alum.

FORMULAS FOR FORMING CO_2 IN BREAD

$NaHCO_3$	$+C_2H_5O.COOH$	$=C_2H_5O.COONa$	$+H_2O$	$+CO_2$
Baking soda	+ Lactic acid	= Sodium lactate	+Water	+Carbon dioxide
$NaHCO_3$	$+HKC_4H_4O_6$	$=KNaC_4H_4O_6$	$+H_2O$	$+CO_2$
Baking soda	+Cream of tartar	= Rochelle salts		
$6NaHCO_3$	$+K_2Al_2(SO_4)_4$	$=Al_2(OH)_6$	$+3Na_2SO_4$	
	Burnt alum	=Aluminum hydroxide	+Glauber's salt	
		$+K_2SO_4$	$+6CO_2$	
		Potassium sulphate		
$2NaHCO_3$	$+H_4Ca(PO_4)_2$	$=HCaPO_4$	$+HNa_2PO_4$	$+2H_2O+2CO_2$
	Calcium acid phosphate	Acid calcium phosphate	Acid sodium phosphate	
$(NH_4)_2NH_2HCO_2CO_3$	+Heat	$=3NH_3$		$+H_2O+2CO_2$
Ammonium carbonate		Ammonium gas		
$2NaHCO_3$	+Heat	$=Na_2CO_3$		$+H_2O+CO_2$
		Neutral sodium carbonate		

Test for Alum in Baking Powder and Bread.—Make up a saturated solution of ammonium carbonate and also a tincture of logwood by digesting ¼ ounce well-powdered logwood chips in a cup of alcohol. Mix up a little baking powder, biscuit, cake or cooky with a little water. Add a teaspoonful of logwood tincture and an equal amount of ammonium carbonate.

If alum is present, that is, if alum baking powder has been used, the color changes to lavender or blue, and does not disappear on boiling. If alum is not present the color varies from red to pink.

Test for Ammonium in Bread.—Mix some bread or baking powder with a small amount of 16 per cent solution of sodium hydroxide. Boil the mixture. Hold in the steam a piece of red litmus paper, and avoid touching the dish or test tube.

If ammonia is present the litmus paper will turn blue.

Yeast in Making Bread.—The use of yeast in making bread light has been known from ancient times. It may have been found by an accident. Wild yeast is floating in the air everywhere. If dough is left exposed, some of these wild yeast plants are sure to fall into it.

Yeast is raised in large vats with mashed potatoes and hops at a temperature of about 80° F. The yeast grows very rapidly. The water is strained from the yeast by placing the yeast in cheese cloth, after which it is mixed with starch to make it firm, and cut into cakes to be sold as compressed yeast. Sometimes the yeast is dried and sold as dried yeast cakes.

In bread making, the dough is kept in a warm place for a time, during which the yeast acts upon the small amount of sugar which is found in all cereals. The housekeeper always places the dough in a place where the temperature maintained will be such as to make the yeast plants very active. They produce carbon dioxide and alcohol from the sugar. This makes the bread rise, as the heat expands the gas after the bread has been put into the oven. The carbon dioxide and alcohol escape by diffusion. Bread raised by the use of yeast contains no harmful ingredients such as are sometimes left by the use of baking powder. Bread left too long to "rise" will sour, because the yeast plants change the alcohol into an acid. During the process of cooking the bacteria are killed.

Questions

1. Why is carbon dioxide an essential factor in bread making?
2. Why is it not possible to use any acid and a carbonate for generating carbon dioxide in bread?
3. Why are places cut in the dough on top of a loaf of bread?
4. Why do some people prick the top of the bread with a fork?
5. Why is alum baking powder objectionable?
6. Why should we avoid the use of bread made with alum baking powder?
7. What is the best test for the presence of alum? Look up others.
8. Why is bread kneaded?
9. Why are there sometimes large holes in certain parts of the bread?
10. What causes sour bread?
11. What is salt rising bread? (Look this up).

FOOD PRESERVATION AND ADULTERATION

Reasons for Preserving Food.—Food may be preserved when it is easy to obtain, and used months afterwards when the season for such food has passed. Preserved food allows a varied diet which would not have been possible in the early history of man.

Methods of Preservation.—Canning fruits and vegetables is one of the best ways of preserving food, since all air (oxygen) and bacteria may be kept away from the food. The food must be cooked first at a temperature of or above 150° F.

Cold storage keeps food, since most forms of bacteria do not live, or are not very active, below 40° F.

Wrapping fruit in paper helps to preserve it, and prevents the spreading of decay from one fruit to another.

Fruit and vegetables must be kept dry. One of the reasons why vegetables and fruit do not keep as well after being in cold storage is because the food is cold and moisture condenses upon it, affording a place for bacteria to grow.

Chemicals are sometimes used to preserve food. If chemicals are used, they must preserve the food and be harmless. Sugar, salt, vinegar and spices preserve food; also, smoke from smoldering wood preserves food in a harmless way.

Another method of preserving food is through the use of alum, borax, boracic acid, benzoic acid, and sulphites. Although small quantities of such material may or may not be harmful, there is always the danger of large quantities being used. No one needs to use food preserved with any of the above chemicals, for the label on the case or bottle tells whether the food is preserved with them. Using your eyes to read the labels is one of the best rules for purchasing preserved foods. If a bottle of ketchup contains benzoic acid, insist on a brand which does not contain a chemical.

It is true that the law allows the addition of chemicals to foods if they are not in sufficient quantity to be detrimental to health; but there seems to be reason to believe that the continual accumulation of poisons in the human body sooner or later prevents the human system from doing its best, and is the cause of the rapid increase of organic diseases. The best way is to avoid all foods

preserved with such **chemicals.** **Eat food** that you **know** is **wholesome.**

Eggs Preserved.—A 10 per cent solution of silicate of soda (water glass) is used extensively for preserving eggs. It forms a thin film over the egg, preventing bacteria from entering.

Questions

1. What is the best way to preserve foods?
2. Why should we avoid all food preserved with alum, boracic acid, benzoic, etc.?
3. Why does water glass preserve eggs?
4. Why should paper be wrapped about fruit?
5. What is the best way of preserving ketchup?
6. Why should the use of saccharin in food be objectionable?
7. Why do doctors use it as they do other medicines?
8. Name some medicines in the same class as saccharin which we would not think of taking unless we were ill.
9. What is apt to be the condition of soda fountain goods that are preserved with benzoic acid? ($\frac{1}{10}$ of 1 per cent.)
10. Why are bottles containing liquid often deceptive as to the amount of contents? (Refer to Illustration, page 244.)
11. How can you compare the contents of bottles?
12. Compare the capacity of extract bottles with some medicine bottles.
13. Examine the labels on your ketchup bottle, can of peas and other canned foods.
14. Make an exhibit of all the different containers of foods and labels you are able to obtain.

SIMPLE PURITY AND ADULTERATION TESTS

To Decide the Freshness of an Egg.—Candling is one of the methods most frequently used. In a darkened room hold an egg between the eye and an artificial light. A fresh egg should appear unclouded and almost translucent. If dark spots are found, it is stale. A rotten egg appears dark colored.

Against the large end of a fresh egg, between the shell and the lining membrane, a small air cell should be distinctly visible. In an egg which is not perfectly fresh this space is filled by the egg substance, unless the egg has been stored with the large end up.

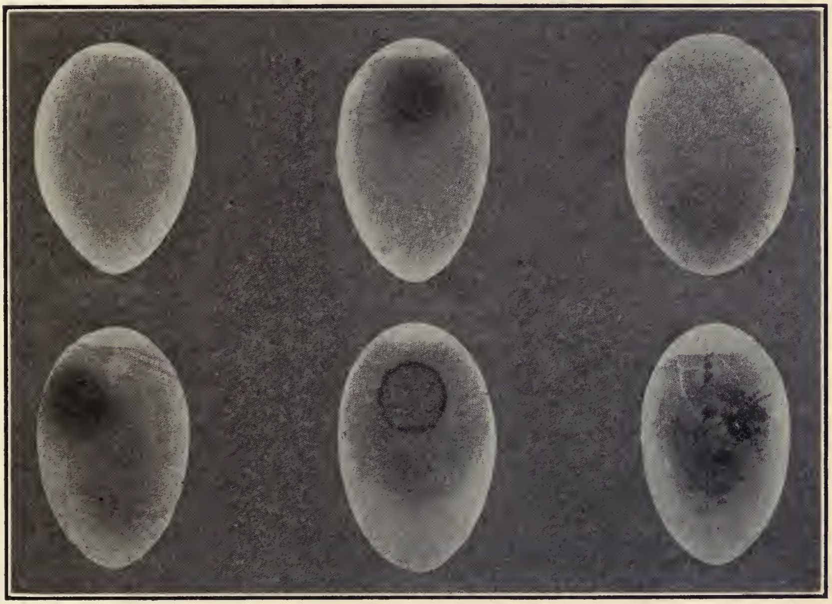


FIG. 148.—Egg test as determined by Bureau of Chemistry, U. S. Dept. of Agriculture. Hold an egg before a candle, gas or electric light. 1. If it looks like the first egg it is fresh. 2. If it looks like the second egg (top row), showing a red spot, it is slightly stale. 3. If it looks like the third egg (top row), settled at the bottom, it is stale. 4. The first egg (bottom row) is stale and the yolk is adhering to the shell. 5. The second egg (bottom row) shows a blood ring. 6. The last egg shows a black mold. It is stale and bad.

Salt solution test: As the density of an egg increases by the evaporation of moisture, its freshness may be approximately estimated by placing it in brine. Prepare the salt solution by dissolving two ounces of salt to one pint of water. Immerse the egg in the

solution. A perfectly fresh egg will sink; if several days old, it will swim just immersed in the liquid; if stale, it will float on the surface.

Shake an egg, holding it near the ear. The contents of a fresh egg should not move. If a slight movement can be detected, it is somewhat stale; if it rattles, the egg is spoiled.

Open the egg and observe the odor and taste. If there is a tendency for the white and yolk to run together, the egg is not fresh, or the hen has been improperly fed.

Milk Test for Bacteria.—Curd Test: The presence of a large number of bacteria in milk indicates staleness or an unsanitary condition. The following test will give some indication of its degree of impurity:

Place 1 pint of milk in a pan surrounded by hot water. When the milk is heated to body temperature, add one junket tablet which has been dissolved in one tablespoonful of warm water. Stir until thoroughly mixed and then wait until the milk has clotted well. Cut the curd in cross-sections with a knife, and carefully pour off the whey. From time to time draw off the whey as it accumulates. When the curd is compact, cut it with a knife and observe its condition. If it is firm and smooth, with but few holes, the milk does not contain an abnormal number of bacteria. If the curd has a spongy appearance, bacteria are present which have produced gas. Place a tablespoonful of the curd in water; if it sinks, the milk is comparatively clean; if it floats, the milk is stale or in an unsanitary condition.

Oleomargarine.—Oleomargarine is made by churning oleo oil, neutral oil, cotton seed oil, and peanut oil, with milk. Oleo oil is obtained from beef fat. Neutral oil is melted lard. This food has as much food value as butter, and is slightly more digestible. It is sometimes colored with coal tar dye to resemble butter.

Renovated Butter.—Renovated butter is made from old and rancid butter. Air is blown through the fat to remove the unpleasant odor. The liquid fat is then churned with milk to produce the butter.

Butter Test.—To distinguish between genuine butter, renovated or process butter, and oleomargarine, the " spoon " test may be used.

Heat in a tablespoon a piece of butter about the size of a cherry, stirring with a match. On boiling, genuine butter makes little noise, but produces much froth; renovated butter boils noisily with a small amount of foam, while oleomargarine boils with more or less sputtering, and produces no foam.

Coal Tar Yellow in Butter. The custom of coloring butter is extensively followed in the United States. Vegetable dyes were employed largely in the past, but coal tar products (aniline dyes) are now quite frequently used. Coal tar yellow may be detected by the following experiment:

Into a weak solution of alcohol put one teaspoonful of butter, a small amount of cream of tartar, and bits of white silk or wool. Boil the mixture. If coal tar coloring is present, the samples will be dyed.

Canned Goods.—Domestic canned goods are very rarely adulterated with preservatives or coloring matter. A few simple tests, however, can be made to detect imperfect sterilization, defective containers, and the amount of solid matter present.

Before opening observe the ends or heads of the can. Any internal gas pressure due to bacteria action will cause the can to bulge. A concave appearance indicates no internal pressure. Make a very small hole in the can. Note if there is an escape of gas. If there is any indication of the presence of gas, the contents should be rejected, as the can has not been properly sterilized or has been imperfectly sealed. In either case decomposition has been taking place, and gases have formed through the action of micro-organisms.

When peas have been imperfectly sterilized, a gas is frequently produced which is soluble in the liquid. In such a case decomposition has taken place, but no escape of gas can be detected when the can is pierced. The liquid, however, is intensely acid, and has a muddy appearance.

Note the condition of the can. If it is rusty, old, or soiled, it should be looked upon with suspicion. Examine the inner surface. If it is corroded, the contents of the can may have dissolved the metal.

Compare the expensive and cheap varieties of canned goods by weighing the solid matter and measuring the liquid in each can.

As a rule, coloring matter is not added to domestic goods. Imported varieties, as green peas, having an intense color, usually have had copper compounds added in small amounts. It may be detected by:

adding a few drops of hydrochloric acid to a portion of the material and dropping on a bright steel nail or the blade of a knife. If copper salts are present, a reddish color will appear on the steel.

Saccharin.—Saccharin is frequently added to canned corn and other food products to give sweetness. It is a substance one part of which is supposed to have as much sweetening power as 300 parts of sugar. For this reason it is frequently used as a substitute for sugar.

Saccharin may be detected by shaking 2 or 3 tablespoonfuls of the suspected liquid in a bottle with an equal amount of chloroform, which may be obtained from a druggist. Saccharin is soluble in chloroform, but sugar is insoluble. With a medicine dropper remove some of the chloroform from the bottom of the bottle. By gently heating in a small dish, evaporate the chloroform. Taste the residue. If it is sweet, saccharin is present.

Saccharin is a poisonous drug obtained from toluene, a product of coal tar. Physicians prescribe the drug in place of sugar for people suffering from diabetes. In such cases only small quantities are to be used, as it is more or less injurious.

Coffee.—When bought in the bean form coffee is not apt to be adulterated. It may, however, be carefully sifted to remove all dirt, dust and small foreign bodies.

Examine the beans and remove all those which are imperfect, split, or defective. Weigh the perfect beans and estimate the amount removed.

Ground coffee is more frequently found to be adulterated, as foreign matter is not as easily detected when the material is finely divided. Chicory is the chief adulterant, although beans, peas and cereals have been more or less used. By the use of a magnifying glass it is possible to pick out particles which are not coffee. Chicory has a dark-looking gummy appearance, and is not granular in character. Peas and beans often have a polished surface, whereas coffee appears dull.

If a tablespoonful of the suspected ground coffee be thrown into a glass of cold water, much of the coffee will float, for it contains a small amount of oil. As a rule, coffee substitutes are heavier than water, and will sink to the bottom.

To Detect Chicory.—Add the ground material very gradually to a glass of cold water. Chicory will make a brownish streak as it sinks to the bottom. The deeper coloring of chicory is caused by caramel which has been produced

during the drying operation in its preparation for the market. Compare with a sample of coffee.

Coffee substitutes generally contain starch which may be easily detected by its giving a characteristic blue with iodine.

Moisten one tablespoonful of the coffee with cold water, add one cup of warm water, bring to the boiling point, and boil for two minutes. Filter through a funnel lined with cotton. The coloring may be removed by passing the liquid through charcoal. When cold, add a few drops of weak iodine; a blue color will appear if cereals, peas, beans or other starch-containing substances are present.

Vinegar.—Vinegar has been very largely subject to substitution and imitation. The best varieties on our market are cider, wine, and malt vinegar.

Substitution may be detected by slowly evaporating almost to dryness one-half cup of vinegar in a small saucepan and examining the warm residue. If there is a distinct odor of baked apples, it is cider vinegar; of grapes, it is wine; of malt, it is malt vinegar. Distilled vinegar gives a burnt sugar odor. No residue indicates synthetic vinegar.

All these products are harmless. Synthetic vinegar is the nearest approach to pure acetic acid, but, as it contains less dissolved material, it lacks flavor. As a rule, cider or wine vinegar is preferred in this country, though in England malt vinegar is largely used.

Extracts of Lemon and Vanilla.—Oil of lemon is soluble only in strong alcohol.

Dilute a portion of the suspected extract with water. If it becomes cloudy, it is oil of lemon, being thrown out of solution by the weakened alcohol.

If the sample remains clear after the addition of water, a substitute has been used. Oil of lemon is much preferred to any substitute.

Vanilla extract: The substitution of a synthetic product, artificial vanillin, is frequently practiced.

As it is usually colored with caramel, it may be easily detected by thoroughly shaking the mixture and observing the foam. If caramel is present, the color remains at the point of contact of the bubbles with the liquid until the bubbles disappear. The foam of the pure extract is colorless.

The flavor of the tonka bean to some extent resembles that of the vanilla bean, but it is cheaper and inferior. It may be detected by its pungent odor.

FIG. 149.—Three Bottles of Extract (front and side views).

This shows the impossibility of correctly estimating the quantity of contents from apparent size of the container. The bottle which is apparently smallest holds the most, and vice versa.

Olive Oil.—Olive oil is sometimes adulterated with cottonseed oil or other cheaper oils.

Experiment. Add 5 c.c. of nitric acid to 5 c.c. of oil in a test tube. Shake. Pure olive oil turns from pale to dark green in a few minutes. If it changes to red, white, orange, yellow, or rose, foreign oil was added. Olive oil, on standing, becomes a yellow solid.

The following table will show how to detect what oil the olive oil was adulterated with:

BACH'S TABLE FOR OIL REACTIONS

Kind of Oil.	After Agitation with HNO_3.	After Heating for Five Minutes on Water Bath.	Consistency after Standing Twelve to Eighteen Hours.
Olive	Pale green	Orange to yellow	Solid
Peanut	Pale rose	Brownish yellow	Solid
Rape	Pale rose	Orange yellow	Solid
Sesame	White	Brownish yellow	Liquid
Sunflower	Dirty white	Reddish yellow	Buttery
Cottonseed	Yellowish brown	Reddish brown	Buttery
Castor	Pale rose	Golden yellow	Buttery

Honey.—Sometimes glucose is used to adulterate honey.

Dissolve by heating three teaspoonfuls of honey in an equal amount of water. Cool and add a few drops of a dilute solution of potassium iodide. The honey should remain pale, if pure. If the color is removed, glucose was added. If starch was added, a blue to purple coloration will appear.

Tests of Food Adulterations (reference books).—A splendid book on food analysis is published by D. Van Nostrand Co., *Detection of Common Food Adulterants,* by Edwin M. Bruce; *Elementary Applied Chemistry,* Lewis B. Allyn, is another good book, published by Ginn & Co.

Other books on food are *Fight for Food,* by Leon A. Congdon; *Side-Stepping Ill Health,* Edwin F. Bowers; *Starving America,* by Alfred W. McCann; *Source, Chemistry and Use of Food Products,* by E. H. S. Bailey; *Pure Foods,* John C. Olsen; *Practical Physiological Chemistry,* Philip B. Hawk; *Food Analysis,* H. Leffman and W. Beam, and *Agricultural Bulletins,* U. S. Department of Agriculture.

NOSTRUMS

Health.—Good food, plenty of pure air and an abundance of exercise produce healthy people. The kind of food we eat and the

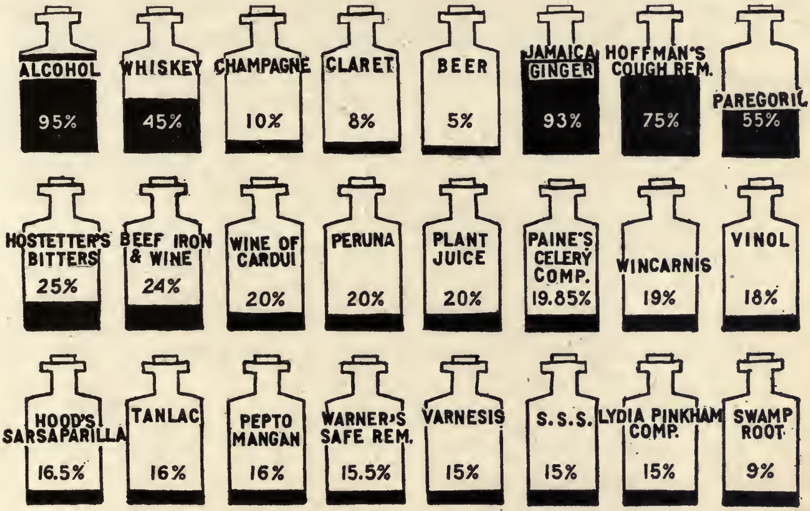


Fig. 150.—How many medicines have as much alcohol as beer? Claret? Champagne? Whiskey? What medicine is free from alcohol? Examine the bottles you have at home and determine from the label the amount of alcohol used.

way we eat it govern our health to a large extent. Too many people are trying to doctor themselves with "patent medicines" which are not only useless but positively harmful. If one is suffering from any ailment, he should go to a reliable physician. He will be able to diagnose the case better than any "Patent Medicine" man who may or may not have had any medical practice.

Alcohol in Medicine.—Every year thousands of people are spending millions of dollars in purchasing patent medicines. Millions of gallons of alcohol and a large quantity of opiates and narcotics, ranging from powerful, dangerous heart depressants to strong stimulants, are thus consumed each year. The diagram shows the per cent of alcohol in many of the "patent medicines" on the market to-day as compared with the amount of alcohol in liquors.

Composition of Some "Patent Medicines."—Some of our widely sold "patent medicines" have been found to contain dangerous or useless substances, such as burned sugar and alcohol with a flavor added. Rochelle salts and olive oil has been sold as a stomach remedy. Dilute hydrochloric and sulphuric acids are used in many medicines which do not contain alcohol. These are sometimes called microbe killers, etc. Such medicines have been advertised to cure:

Asthma	Goiter
Abscess—Anemia	Gout
Bronchitis	Hay Fever—Influenza
Blood Poison	La Grippe
Bowel Troubles	Leucorrhea
Coughs—Colds	Malaria—Neuralgia
Consumption	Meningitis
Contagious Diseases	Piles—Quinsy
Cancer—Catarrh	Rheumatism
Dysentery—Diarrhea	Scrofula
Dyspepsia—Dandruff	Skin Diseases
Eczema—Erysipelas	Tuberculosis
Fevers	Tumors—Ulcers
Gallstones	Throat Troubles

One medicine alone has been advertised as able to "cure" or "remedy" any and all of the diseases mentioned. Such words as "cure" have been removed from the label of a great many patent medicines and the word "remedy" substituted because they were fraudulent and unable to cure any disease and because the Food and Drug Act prohibits fraudulent claims on the trade package. Some-

times a patent medicine has even the word "remedy" omitted, and the word "for" alone stands out to deceive the public.

Poisons.—Many deaths, as well as permanent injury to health, have occurred through the use of headache powders and pills which

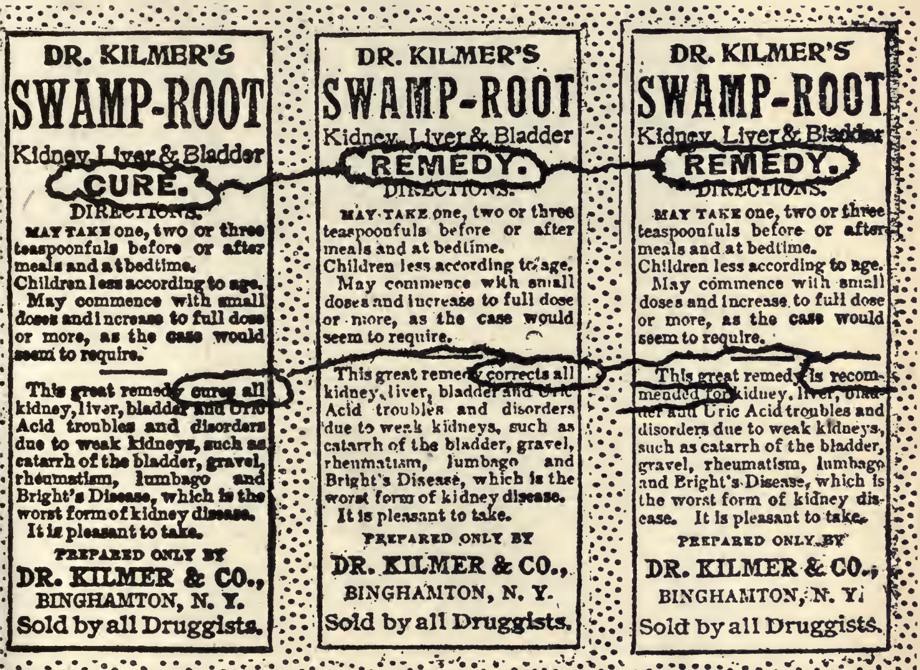


FIG. 151.—The evolution of the Swamp Root Label since the Pure Food Law passed. Why do you think the word "Cure" was changed to "Remedy"? Why do you think the statement "cures all" was changed to the mild statement "is recommended for"? The illustration is only one of many.

contain some drug, such as **phenacetin, acetanilid, morphine, opium, heroin, alcohol and chloral.** The best rule for those who wish to attain the highest physical and mental efficiency is to avoid all types of habit-forming drugs. One who forms the habit of taking these medicines may become so addicted to the use of them that it

will be almost impossible to stop, just as a morphine eater finds it impossible to keep from using this awful drug.

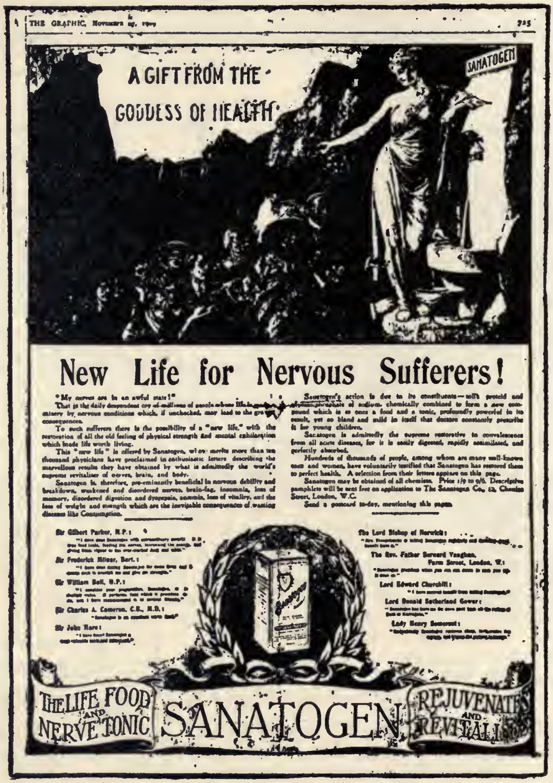


FIG. 152.—Casein makes up about nine-tenths of this medicine. Casein is known in its commonest form as curd in milk or cottage cheese. Do you think cottage cheese would be a "Re-creator of lost health"? Do you think the curd of milk would give "New Life for Nervous Sufferers," or is to be considered a "Gift from the Goddess of Health"? This medicine contains compounds of phosphorus and glycerin, but not enough to be considered of any value as a food.

Such medicines as:

Orangeine	Dr. Davis' Headache Powders
Bromo-Seltzer	Antikamnia

Royal Pain Powders	Ammonol
Miniature Headache Powders	Salacetin
Megrimine	Cephalgin
Anti-Headache	Phenalgin

depend for their results upon the heart-depressing action of acetanilid or phenacetin, and should never be taken without a doctor's prescription.

Test for the Presence of Acetanilid (Ritsert's Test). Boil 1 gram of the sample in a small beaker for two or three minutes with 3 c.c. of strong hydrochloric acid. Divide in two portions in test tubes. To one test tube add three drops of a solution of bleaching powder in such a manner that the two liquids do not mix. A beautiful blue at the junction of the two liquids denotes the presence of acetanilid. To the other test tube add a drop of potassium permanganate. A green color signifies the presence of acetanilid.

Causes of Headaches.—Headaches may be caused by the liver, malaria, infected blood, the stomach, the ears or eyes. Sometimes

FIG. 153.—Bromo Seltzer contains potassium bromide, acetanilid, and caffein. This is a very dangerous nostrum, for deaths have followed the taking of overdoses. It does not cure headache since it cannot remove the cause. It acts as a heart-depressing medicine.

a poison caused by fermentation forms in the intestines and produces headaches of the worst type. This poison is considered very dangerous, and, if isolated and injected directly into the blood, would kill a person as quickly as the poison of a cobra. However, this poison is not readily absorbed by the blood. Constipation allows a great deal of this poison to collect in the system. The removal of this cause relieves many headaches.

Shop girls and overworked people often gather in their systems a fatigue poison which accumulates faster than the oxygen can carry it off. Headaches caused by study rooms and long, tiring speeches are due to fatigue poisons.

Sour stomachs, biliousness, eye strain, indigestion caused by foods which should not be eaten, caffein stimulation from the drinking of coffee to excess, and the over-use of tobacco, are causes of headaches. Headache powders or tablets containing acetanilid do not cure such troubles. They simply cover up the true cause of the trouble and may develop a "dope" habit. The removal of the cause is the best way to cure headaches. A physician will remove the cause.

FIG. 154.—The name Pa-pay-ans has been changed to Bell-ans as the illustration shows. The nostrum consists essentially of charcoal, ginger, baking soda and oil of wintergreen. Any physician could prescribe a far better remedy. The name originally suggested the presence of papain, obtained from a fruit. Why do you think the name was changed?

Soothing Syrups.—Many of the soothing syrups so widely advertised contain **laudanum, opium,** or **morphine.** Some contain **potassium bromide.** Paregoric is essentially a compound containing **opium** and **alcohol.** The soothing syrup containing laudanum is more dangerous than many of the other preparations. The use of all soothing syrups should be carefully avoided.

Cough Syrups.—In addition to alcohol, many of the cough syrups contain morphine, ether, or chloroform. The amount of alcohol varies from 3 per cent to 75 per cent. Some of the cough syrup labels recommend that the medicine be used for:

Colds
Croup
Coughs
Pneumonia
Bronchitis
Sore Throat
Weak Throat
Pains in Head
Tickling in Throat
Difficult Breathing
Symptoms of Croup
Difficult Speaking
Spitting of Blood
Whooping Cough
Loss of Voice
Weak Lungs
Hoarseness
Pleurisy
Asthma
Grippe

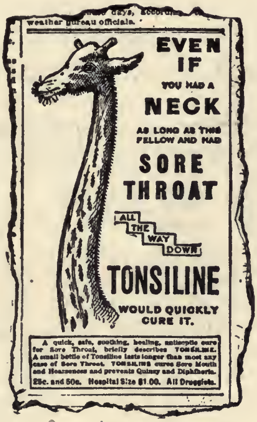


Fig. 155.—The Chemists of the American Medical Association have analyzed Tonsiline and report that a product having essentially the same composition as Tonsiline would be: Tincture of chlorid of iron (ferric chloride), U.S.P., 1 ounce; alcohol, 1 ounce; potassium chlorate, 280 grains; water, sufficient to make 1 pint. It is not necessary to tell physicians that Tonsiline never cured sore throat nor prevented diphtheria. The stuff contains drugs whose use for these purposes by the medical profession is being abandoned. The risk of poisoning from the use of potassium chlorate, while well known to the medical profession, is still but little appreciated by the public. The dangers of the indiscriminate use of a "patent medicine" containing, as Tonsiline does, a saturated solution of chlorate of potash, by individuals who may be suffering from kidney disease, will be evident to every physician, but not to the layman.

These medicines do not **cure** coughs, as they do not remedy the cause.

Incurable Diseases.—Patent medicine manufacturers thrive on people who have incurable diseases. A mixture of chloroform, prussic acid, and cinnamic acid has been sold to people as a "cure" for consumption. People should avoid all "Sure Cure" medicines and those advertisements which tell about "Good News," "Cancer Cures," "Herald of Health," etc.

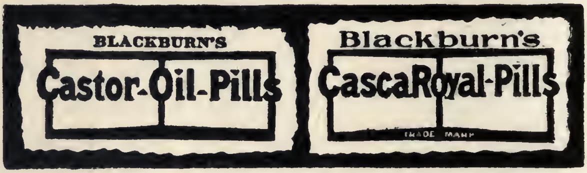
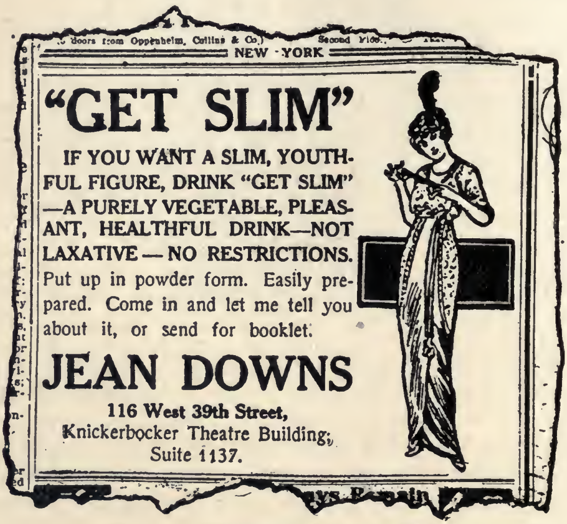


FIG. 156.—Before and after the passage of the Food and Drug Act. Why do you think it was necessary to change the word "Castor" to "Casca"?



Courtesy of American Medical Association.

FIG. 157.—This "obesity cure" was found to consist of: 1. Sugar, colored pink. 2. Baking Soda. 3. Cream of Tartar.

Hair-growing Fakes.—In many newspapers are to be found advertisements of medicines for making hair grow. Most of these medicines are composed of useless materials and have never been known to make hair grow.

Obesity Cures.—Some of the "Get Thin" medicines are nothing but powders composed of sugar, baking soda, and tartaric acid, colored pink. Other flesh reducers contain Epsom salts, camphor, soda and citric acid. They are sold at an enormous price, and are perfectly useless for flesh reducing, but may be destructive to the health if used in large quantities.

FIG. 158.—This medicine was found to contain a dangerous substance called *Thyroid gland*, the use of which is fraught with danger even under skilled medical supervision. Why should the sale of such medicines to the public be allowed?

From Committee on Interstate and Foreign Commerce. Courtesy of A. M. A.

Another preparation which has been sold for the purpose of reducing flesh is an ointment consisting largely of soap. The purchaser is supposed to rub this on the body until the superfluous fat is rubbed away.

Still another method for reducing flesh is to put in the bath a preparation composed of Epsom salts and washing soda. This costs the manufacturer but a few cents, but is sold for one dollar.

Obesity is generally due to improper diet and lack of proper exercise. In most cases the correct diet with light, persistent exercise will bring about reduction in weight.

Too much flesh is of course a handicap from the standpoint of appearance, comfort and health. However, the stout person has a better chance of recovery from fever, since the fever burns up the tissues of the body unless there is a quantity of surplus fat to be oxidized.

Insurance companies consider that people who are carrying ten or fifteen pounds in excess of the standard weight for their age and

height have a twenty per cent better chance of escaping tuberculosis than thin people or people of normal weight.

Make a collection of "patent medicine" bottles. Send to the American Medical Association, Chicago, Ill., for books on Frauds, Nostrums and Quack-

FIG. 159.—This instrument consisted of a metallic cylinder filled with coke dust or carbon black. From the device runs a silk cord on the end of which is a band for attaching the cord to the wrist or ankle. The instrument is to be placed in water and the cord attached to the patient during the night. It was declared a fraud by the U. S. Government.

ery, and also to the Department of Chemistry and to the Department of Agriculture, Washington, D. C., for Analysis of Patent Medicines.

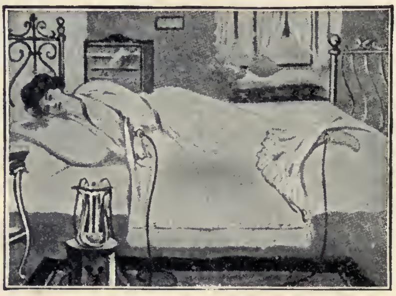


FIG. 160.—Such frauds as these have been sold by the manufacturer who claims they will cure many ailments. The instrument in many cases was made of a piece of brass pipe filled with worthless material. Oxpathor, Oxydonor, and Oxygenator are frauds of this type.

Deafness Cures. The market is flooded with all kinds of cures for deafness. All "patent medicines" or patent devices for curing deafness may be considered fakes. Dr. Graham Bell, the inventor of the telephone, endowed an institution for giving people who are losing

their hearing free instruction in lip reading. A deaf person may use an ear trumpet or some other device for collection sound waves, but such devices do not cure deafness and some may be very dangerous. If one is so unfortunate as to be deaf, learning how to read the lips is about the only method a person has of clearly understanding what another says.

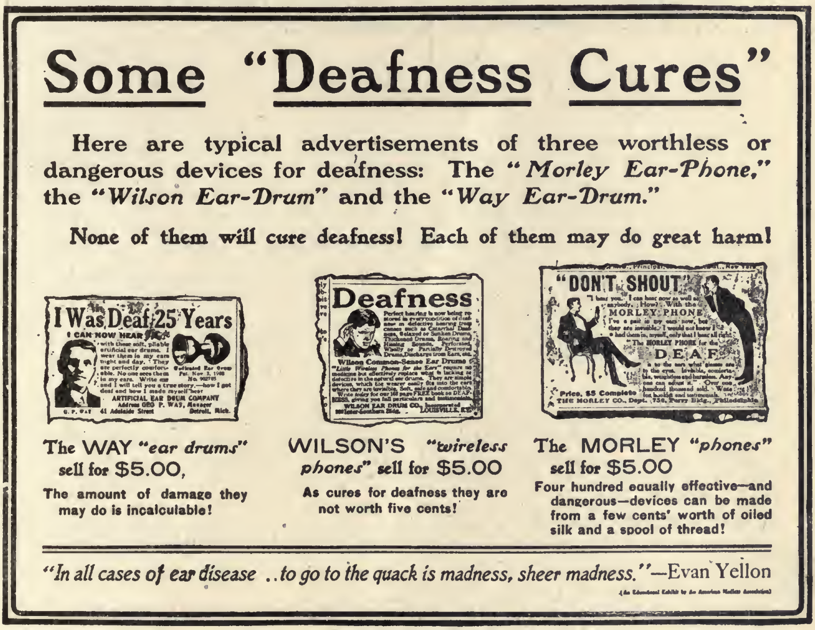


FIG. 161.

Water as a Medicine.—A person should drink an abundance of water, as it has a cleansing effect on the body. If taken before eating, it clears out and washes the stomach. Water also dilutes the blood, assisting in carrying off waste matter, such as uric acid.

There are many so-called mineral waters which, it is claimed, have curative value because they contain certain salts and chemicals. In most cases where people have been cured by drinking such waters it is probably because of the air, exercise, and out-door life which

they have at the famous springs or seashore resorts. Many of these waters are no better than any good clear drinking water.

Some water which is bottled and sold to the public as coming from certain springs is merely ordinary water, obtainable in any locality, to which has been added Glauber's salts, Epsom salts, common salts, etc.

Send for pamphlet, "Mineral Water sold under Misleading or Fraudulent Claims," American Medical Association, Chicago, Ill.

Questions

1. How do some patent medicines, as a rule, compare with liquors?
2. What medicines are dangerous? Why?
3. Why should we always read the labels of bottles?
4. Why should we avoid all medicines which do not state the contents of the bottles on the labels?
5. Why are medicines frauds which claim to "cure," or to "remedy" many ills?
6. Why are children apt to form the taste for alcohol and dangerous opiates if they are fed cough syrups and soothing syrups?
7. Why may people who regularly take headache powders form a "dope habit"?
8. Why should people who have incurable diseases avoid patent medicines?
9. Why are hair-growing tonics fakes?
10. What is the best cure for obesity?
11. Why should people who are too stout avoid all obesity cures?
12. Why is water a good medicine?
13. Why should people not use bottled waters without finding out the contents of the water?
14. What is the chief objection to buying patent medicines even if they contain no injurious material?
15. Why should people never buy a "patent medicine" for serious ailments?
16. What do you consider of greatest value in this section?

CHAPTER VIII

WATER

FACTS ABOUT WATER

Water.—Water is one of the most abundant and widely distributed compounds on earth. Since it is a solvent for many substances it is never found pure in nature. When pure, however, it is tasteless, colorless and odorless. Water is found in the majority of things about us, the papers we use, the wood in our homes, the food we eat. For example, eggs and potatoes are three-quarters water, solid rocks contain water, and even our own bodies are 65 per cent water.

Composition of Water.—Water is composed of two gases, hydrogen and oxygen. These gases are called **elements**. An element is a substance which can not be decomposed into simpler substances. Scientists have found that there are only about 83 different elements, but by combining them in different proportions various kinds of substances may be obtained. Thus by combining 2 parts of hydrogen with 1 part of oxygen, water is obtained.

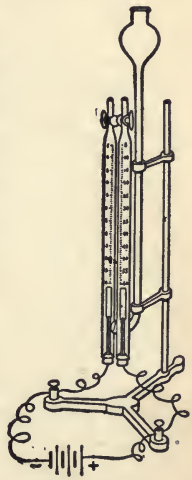


Fig. 162.

Electrolysis.—Water may be separated into its elements through a process called **electrolysis.** Water is poured into the bowl of the apparatus shown in the diagram until the two upright tubes are full of water. A little sulphuric acid is added, as the acid allows the current to pass through the water. A battery is attached to the two platinum sheets in the water at the bottom of the instrument. Bubbles of hydrogen will be seen to rise in one tube and bubbles of oxygen in the other. This process of separating the water into its elements to determine its composition is called electrolysis.

Specific Gravity.—A knowledge of the density or specific gravity of a liquid or a solid is often important to determine the purity or condition of materials. In the preparation of syrups, jellies and other food products, the determination of their specific gravity is a very convenient way of knowing whether the process of evaporation or "boiling down" has been sufficient.

The condition of milk as to its fat content may be determined by measuring the specific gravity of milk, which is from 1.028 to 1.032. If the specific gravity is above this, the probability is that cream has been removed.

The purity of gasoline may be determined by its specific gravity. Gasoline has a specific gravity of 0.70 to 0.74. If the specific gravity of the gasoline is different from this we know that the gasoline is impure, and not of standard grade.

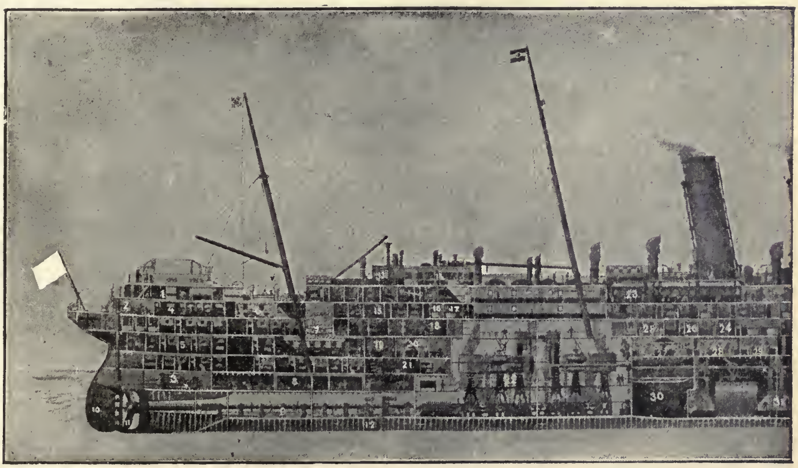
Electric storage batteries used in automobiles, etc., are tested as to their specific gravity to determine whether they are fully charged. A battery reading 1.300 is overcharged, while a battery reading 1.280 is fully charged. If the reading is below this specific gravity, the battery is undercharged.

Meaning of Specific Gravity.—Specific gravity is the relation between the weight of a substance and that of an equal volume of water. For example, zinc has a specific gravity of 7, which means that a cubic foot, cubic inch, or cubic centimeter of zinc is 7 times heavier than a cubic foot, cubic inch or cubic centimeter, respectively, of water. The weight of water is taken at 4° C. or about 39° F. (Refer to page 114). Therefore, a good definition of specific gravity is: the ratio of the weight of any volume of a substance to the weight of an equal volume of water.

The human body has a specific gravity of 1.07, which means that a person is slightly heavier than water. A cubic foot of water weighs 62.5 pounds per cubic foot. The human body then would weigh 66.8 pounds per cubic foot.

Floating and Sinking Bodies.—Place a wooden ball in a dish of water. It will be seen to sink to a certain depth and then float. Place a metal ball of the same size in water. It will sink. Weigh the metal ball out of water (using a spring scale). Weigh the metal ball in water. **It will be seen that the metal ball has lost weight.** If possible, obtain a larger piece of metal,

a



b

Fig. 163*a* and *b*.—This great ocean liner must sink in water until the water displaced equals the weight of the ship, the weight of the people, and all material on board.

such as a small cannon ball; or a croquet ball loaded with metal will answer the purpose. If a small ball is used, place the ball in a graduate so as to measure the amount of water displaced or pushed aside. The increase in height of the water in the graduate will show the amount of water displaced by the ball. Weigh an equal amount of water. Weigh the ball in water. Compare the weight of the water with the loss of weight of the ball. If the croquet ball is used, fill a dish as full of water as it will hold. Place the ball in the dish, catching in a pan the water which overflows. Weigh the water which has been displaced by the ball. Compare the loss of weight of the ball with the weight of the water displaced.

A body floats when it sinks into a liquid to such a point that the weight of the liquid displaced by the body is equal to the weight of the body. If the body can not displace enough water to equal its own weight it sinks, but it loses as much weight as the weight of the water it displaces.

A ship weighing 50,000 tons must push aside 50,000 tons of water. A cubic foot of water weighs about $62\frac{1}{2}$ pounds. If a body displaces a cubic foot of water, it loses $62\frac{1}{2}$ pounds of its weight. Because of these facts, architects and engineers are able to tell the weight of granite piers, steel columns, etc., without weighing them, since they know how many times heavier than water each cubic foot of material is.

Submarines as Sinking and Floating Bodies.—An excellent illustration of how the submarine sinks and floats is the bobbing bottle.

Fig. 164.

Fill a flat-sided quart bottle full of water, and invert in it a small pill bottle containing enough water to just allow it to float. Cork the bottle, and adjust the stopper so that the little bottle inside will just float. Press on the sides of the big bottle. Since the glass is elastic, the sides will give slightly, forcing water up into the little bottle, and slightly compressing the air. The bottle will sink. If the pressure is relieved, the compressed air will expand, forcing the water out of the little bottle which will rise.

A submarine has large air tanks into which water is pumped to make the submarine sink. When the submarine wishes to rise the water is forced out. The submarine then displaces a weight of water greater than its own weight—a result which causes it to rise to the top and float.

Hydrometers.—Because of the fact that a body sinks in liquid until the weight of the liquid displaced is equal to the weight of the body, an instrument called the hydrometer may be used for measuring the specific gravity of liquids. The hydrometer is weighted at the bottom with a long stem on which there is a graduated scale. The depth to which the hydrometer sinks gives the specific gravity of the liquid.


Fig. 165.

There are three classes of hydrometers:

1. The specific gravity hydrometer indicates the number of times heavier the liquid is than an equal volume of water.

2. The per cent hydrometer indicates the per cent of a substance present. This hydrometer is used for determining the per cent of alcohol, water, etc. The amount of water in maple syrup is easily determined by this hydrometer. The density of maple syrup varies from 1.32, with 35 per cent water, to 1.34, with 32 per cent water.

3. The arbitrary scale hydrometer indicates the concentration of strength of a substance. The lactometer is an example of this hydrometer, and is used for measuring the specific gravity of milk.

Look up uses of hydrometer.
What does the word mean?

Use of the Hydrometer.—In using the hydrometer a portion of the liquid whose specific gravity is to be measured should be placed in a glass cylinder of such a size that the hydrometer when placed in the cylinder will be free to move up and down without coming in contact with the walls of the vessel. The liquid should be well stirred. For specially accurate work the temperature of the liquid should be observed by means of a thermometer placed directly in the liquid. When the temperature has become fairly constant the readings on the hydrometer may be taken.

Water Pressure.—Since a cubic foot of water weighs about $62\frac{1}{2}$ pounds, the greater the amount of water in a reservoir or tank, the greater will be the pressure on the bottom and sides of the container. For every $2\frac{3}{10}$ feet increase in depth the pressure in-

creases 1 pound per square inch. If an object were 10 feet under water, the pressure on that object per square foot would be 10 times $62\frac{1}{2}$ pounds (625 pounds per square foot) or 4.34 pounds per square inch, since the increase in pressure is .434 pound per square inch for each foot in depth.

DENSITIES OF SOME HOUSEHOLD MATERIALS

Substance.	Temperature in Degrees Centigrade.	Density in Grams per Cubic Centimeter.
Air, dry	20 (68° F.)	0.001205
Air (of 50 per cent humidity)	20	0.001195
Brine (5 parts by weight of salt in 100 parts of brine)	15	1.035
Brine (25 parts by weight of salt in 100 parts of brine)	15	1.191
Butter	....	0.86 –0.87
Cider vinegar	....	1.013–1.015
Cream* (18 per cent butter fat)	20	1.01
Cream (40 per cent butter fat)	20	0.99
Gasoline	20	0.70–0.74
Ice	....	0.92
Kerosene	20	0.78 –0.82
Lard	....	0.92
Linseed oil	20	0.92 –0.93
Milk	20	1.028–1.032
Olive oil	20	0.91
Sea water	15	1.023–1.025
Syrup, maple †	17.5	1.32 –1.34
Tallow	....	0.91 –0.97
Turpentine	20	0.86 –0.87

* Minimum butter fat content for cream (definition of Bureau of Chemistry).
† The density of maple syrup varies from 1.32 with 35 per cent of water to 1.34 with 32 per cent of water.

This water pressure is so great in the ocean that divers and submarines are unable to go to any great depth. The greatest depth on record to which a diver has gone is slightly over 300 feet. (What would be the pressure on a human being 300 feet under water?)

Some very interesting fish have been found in the ocean at the depth of 3 or 4 miles. Because of the enormous pressure at great depths in the ocean, it was only recently that scientists were convinced that life could exist there.

Use of Water Pressure.—Water pressure is used to turn water wheels, and to run machinery in factories, in electric generating stations, etc. The most popular type of water wheel to-day is the **turbine.**

TABLE OF DENSITIES

Densities in Grams per Cubic Centimeter

Aluminum	2.67
Antimony, cast	6.7
Beeswax	.96
Bismuth, cast	9.8
Brass	8.4
Copper	8.8–8.9
Cork	.14–.24
Galena	7.58
German silver	8.5
Glass, crown	2.5
Glass, flint	3–3.5
Gold	19.3
Iron, bar	7.8
Iron, cast	7.2–7.3
Ivory	1.9
Lead	11.3–11.4
Marble	2.72
Mercury, at 0° C.	13.596
Platinum	21.5
Quartz	2.65
Silver	10.4–10.5
Steel	7.8– 7.9
Sulphur, native	2.03
Tin	7.3
Zinc, cast	6.86

Alcohol (95 per cent)	.82
Blood	1.06
Carbon disulphide	1.29
Chloroform	1.5
Copper sulphate solution	1.16
Ether	.72
Glycerine	1.27
Hydrochloric acid	1.22
Nitric acid	1.5
Sulphuric acid (15%)	1.10
Sulphuric acid	1.8
Water (4° C.)	1.000
Water, sea	1.026

Gases at 0° C. and 76 cm. Pressure

Carbon dioxide	.001977
Hydrogen	.0000896
Nitrogen	.001256
Oxygen	.001430

Water pressure is used for supplying cities and towns with water from either reservoirs or lakes higher than the town, from which the water flows into a standpipe higher than any of the buildings in the town. All water is taken from reservoirs and pumped into a standpipe.

The diagrams will show the different methods of supplying towns with water. It will be seen that the water coming from faucets

on the top stories of high buildings will have less pressure than the water coming from faucets on the bottom stories. Water pressure is reduced by friction of pipes, joints and valves.

Wherever towns or cities are located near mountains the water is piped from lakes or streams that have an elevation greater than the place supplied. Such a system is called a **Gravity System.**

Fig. 166.—These fish live at a great depth in the ocean. The depth is so great that light does not penetrate the waters. In this semi- or total darkness fish must develop their own light to see. Some of the fish have light organs just below their eyes, others have a long slender antenna on the end of which is a strong flash light for searching out their prey. All these fish are carnivorous, since plant life cannot grow at the depth where fish of this type dwell. The tissues of the fish are filled with fluid and loosely knitted together, and the bones are cartilaginous in order to stand the pressure of thousands of pounds to the square inch. When they are brought up from the deep to the surface the tremendous pressure is relieved, causing the exploding gases within the body to bulge out the eyes and to force out through the mouth the heart, liver and intestines.

If cities or towns are located in level places where there are no elevations from which to get water, the water must be pumped into standpipes or reservoirs higher than any building in the town.

Problem.. Investigate the use of the water turbine.

Amount of Water Used.—The amount of water required daily for each person in a family is estimated at from one gallon to four

FIG. 166*a*.—Why does the water in the stand pipe never run over the top? Why is it necessary to have the standpipe higher than the houses? How far away is the standpipe or reservoir from your home?

gallons. Cities which do not have large manufacturing establishments construct water plants which are able to furnish fifteen gallons

FIG. 166*b*.—Why is it necessary to have a pumping station? What kind of pump would be used in a pumping station?

of water per person. In large manufacturing places water plants are so constructed as to furnish 200 or more gallons for each inhabitant.

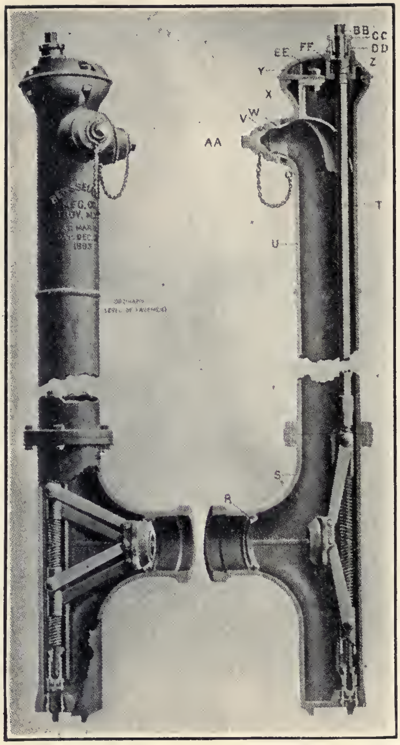


Fig. 167.—X-Ray view of a fire hydrant. Why should automobile drivers be careful to leave their cars several feet from a fire hydrant? Why do you think a valve is placed at the bottom of hydrant to drain it?

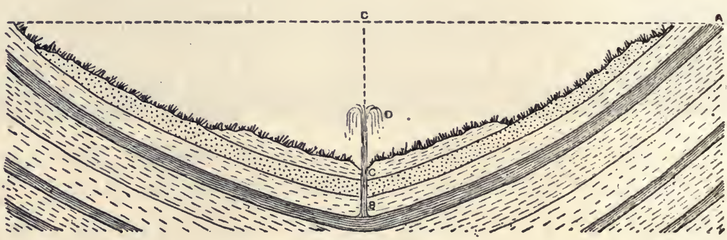


Fig. 168.—Artesian well.

Experiment to Show Water Pressure.—Heat a piece of glass tubing until it is soft. Draw it out to a small jet. Attach one end of the jet to a rubber hose, and place the other end in a dish of water. Fill the tubing with water by sucking the air out. Hold the jet upright, allowing the dish of water to be very much higher than the jet. Raise and lower the dish of water which represents a lake or other source of water supply.

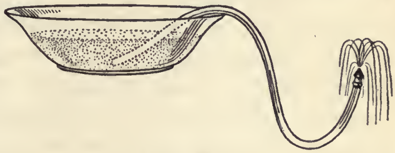


Fig. 169.

What is the relation between the height of the source of water supply and the jet?

What is necessary that we may be supplied with water from our faucets?

Questions

1. Why is it possible for a person to float in water?
2. How much would you weigh in water if you were not trying to float?
3. How much do a boat, engine, people, and material on a boat weigh if the boat displaces 10,000 cubic feet of water?
4. When you get into a rowboat how much more water must the rowboat displace? Why is it easier to swim in salt water?
5. Why will a life preserver which is guaranteed to hold up 20 pounds in water hold up a man weighing 240 pounds?
6. Would a body a cubic foot in size weighing 125 pounds float in water?
7. Why is water more likely to enter the ear during a deep dive than during a shallow dive?
8. What is the weight of a granite monument which has a base 10 feet square, a top 2 feet square, and is 25 feet in height?
9. What would be the pressure on your body per square inch, per square foot, on the entire number of square feet on the body, if you were 10 feet under water? Refer to page 47.
10. What would be the pressure on a body the size of your body which went down with the steamship Titanic 4 miles below the surface of the ocean?

11. How many cubic feet of water do you displace when you dive?
12. How many times heavier is gold than water?
13. How could you tell whether your gold ring is pure or not?
14. Try to find out.
15. Why will a submarine float?
16. What must be done to make it sink?
17. What would be about the pressure per square inch of the water at the faucet in the sink, if the water tank is 12 feet above the faucet and nearly empty? What would be the pressure if there were 7 feet of water in the tank?
18. Why will a board enable a person to walk over a swampy place?
19. Why is a drowning person more likely to sink if he throws up his arms?
20. Why is a fish with a swimming bladder able to rise and sink in water?

CLEANING OF FABRICS

Water as a Solvent.—Water is a solvent for many things, but for such substances as grease, oil, fat, tar, etc., ether, gasoline, and benzine are often used because they dissolve fats or oils which water will not. Whenever oil is shaken with water it breaks up into little fine bubbles (globules) which give the water a turbid appearance. Soon, however, the water and oil will separate. If a substance had been added to the water to prevent the oil and water separating when the oil and water were mixed, the result would be called an **emulsion.** Soap is one of the best emulsifying agents. Dirt or spots on clothing which cannot be taken off with water usually are of a fatty or oily nature. When soap is added to the water the fat emulsifies into fine drops which are carried out of the cloth.

Cleaning of Fabrics.—Many people use ether, benzine, gasoline, turpentine, and other dangerous liquids for cleaning. **Carbon tetrachloride** is the safest solvent, since it is non-inflammable. A good combination for removing fats and oils from clothing is a mixture of **carbon tetrachloride** with **turkey red.** It may be used with cold water in the laundry as a substitute for soap. It readily removes grease from the hands when used with cold water.

Methods of cleaning materials will be found in the table at the end of this section.

Soap.—There are many different kinds of soaps. Perfumed and colored soaps are usually used for toilet purposes. They have perfume added to conceal disagreeable odors. Strong perfumed soap should be avoided, since a great deal of perfume may have been added to conceal a poor quality of soap. **Floating** soaps are made by beating air bubbles into the soap. **Marine** soap is made from palm nut or cocoanut oil, and readily forms lather with sea water. **Medicated** soap contains a variety of medicinal substances, such as carbolic acid, tar, etc. **Scouring** soaps usually contain fine sand, ground slate, or pumice.

To Determine the Kind of Fiber in a Cloth.—Concentrated hydrochloric acid will dissolve silk if a piece of silk is heated in it for about two minutes at a temperature of 125° F.

Wool is dissolved in a 5 per cent solution of potassium hydroxide if the wool is boiled in the solution for about ten minutes.

Cotton will not dissolve in either hydrochloric acid or potassium hydroxide. If a piece of cloth is made of wool and cotton it is easy to determine the amount of cotton present by dissolving the wool with potassium hydroxide.

Experiments.—Boil a piece of silk in hydrochloric acid. If it will dissolve it is probably true silk. If some of the cloth is left undissolved, test for wool; if no more of the cloth dissolves the remaining part is cotton. Test several pieces of cloth to determine the kind of fiber.

To distinguish between linen and cotton, heat a piece of cotton and one of linen for two minutes in a concentrated sulphuric acid. Wash with water and soak in dilute ammonia. The cotton will be changed to a jelly-like mass. The linen will hardly be affected. Another method of determining the difference between cotton and linen is by steeping a sample of each for five minutes in a small amount of olive oil. The linen will appear dark and the cotton light if the samples are placed on a dark background.

To determine the difference between pure and artificial silk, hold a piece of silk in a pair of tweezers and light one end. Pure silk burns slowly with an odor, goes out quickly and leaves a gummy residue. Artificial silk burns rapidly with no odor. True silk turns yellow with nitric acid while artificial silk is not affected.

Silk is sometimes weighted with tin and other metals. Such material does not burn when the silk is lighted.

REMOVAL OF STAINS AND GREASE SPOTS

Make Tests on Different Stains which You may Find at Home.

Nature of Stain.	Silk Goods.	Woolen Goods.	Cotton or Linen.
Blood.	Water, followed by solution of neutral soap in methylated spirit.	As silk goods.	Water, followed by sodium hypochlorite.
Chocolate or Cocoa.	Cover with borax and soak in cold water.	As silk goods.	As silk goods.
Enamel.	As paint, or with a mixture of acetone and amyl acetate.	As silk goods.	As silk goods.
Fruit, tea, coffee, wine, beer.	*White Silk.* Water, followed by potassium permanganate, and removal with sulphuric acid of the brown stain produced.	As silk goods.	Water, followed by sodium hypochlorite.
	Colored Silk. Water, followed by sulphurous acid, or hydrogen of peroxide, if the colors are fast to these reagents; otherwise, methylated spirit and soap.		*Colored Goods.* Aqueous soap solution and ammonia.
Sugar, glue, etc.	Water.	As silk goods.	As silk goods.
Grease, oil, wax.	Benzine, benzol. (See also Paints and Iron Mold.)	As silk goods.	As silk goods.
Paint.	Ether, aniline acetone, nitrobenzine, chloroform, carbon tetrachloride. If old soften with amyl acetate. Then remove with gasoline and gasoline soap. Lacquer may be removed by dissolving linseed oil with amyl alcohol, and the insoluble coloring matter washed off.	As silk goods.	As silk goods.

REMOVAL OF STAINS AND GREASE SPOTS—*Continued*

Nature of Stain.	Silk Goods.	Woolen Goods.	Cotton or Linen.
Sealing wax.	Methylated spirit.	As silk goods.	As silk goods.
Tar and pitch.	Benzine, benzol, aniline or ether.	As silk goods.	As silk goods.
Varnish (oil).	As paint.	As silk goods.	As silk goods.
Varnish (rosin).	Aniline, or methylated spirit, or carbon tetrachloride and a little methylated spirit.	As silk goods.	As silk goods.
Grass stains.	Ether, or soap in methylated spirit.	As silk goods.	As silk goods.
Iron mold.	Aqueous solution of oxalic acid.	As silk goods.	Titanous chloride, with or without hydrochloric acid.
	Cream of tartar and citric acid.		Oxalic acid.
Iron rust.	Gartside's Rust Soap. Follow directions.	As silk goods.	As silk goods.
Ink stains.			
(1) Marking ink (silver).	Solution of potassium cyanide.	As silk goods.	As silk goods.
Marking ink (aniline black).	Aniline, or a solution of benzine soap in chloroform.	As silk goods.	As silk goods.
(2) Copying pad ink.	Methylated spirit and ammonia.	As silk goods.	As silk goods, or, on white goods, dilute caustic soda.
(3) Writing ink.	Dilute mineral acids, or oxalic acid.	As silk goods.	Acetic or formic acid, followed by dilute mineral acids, or oxalic acid.

REMOVAL OF STAINS AND GREASE SPOTS—*Continued*

Nature of Stain.	Silk Goods.	Woolen Goods.	Cotton or Linen.
Iodine.	Dilute solution of potassium cyanide. Wash thoroughly in water, or a solution of pure sodium hypophosphate, and then strong ammonium water. Dry between blotting papers.	Same as silk.	Same as silk.
Varnish (shellac)	Methylated spirit alone, or with carbon tetrachloride.		
Scorch stains.	Potassium permanganate, followed by sulphurous acid, or hydrogen peroxide.	Hydrogen peroxide.	Hydrogen peroxide or sodium hypochlorite.
Color stains (substantive and basic).	*White Goods.* Decorline (or other stable hydrosulphite) and acetic acid, or methylated spirit and ammonia, or hydrogen peroxide.	As silk goods.	*White Goods.* Titanous chloride (warm).
	Colored Goods. As above, if colors are not affected thereby.		*Colored Goods.* Titanous chloride (cold and dilute).

NOTE.—Potassium cyanide is deadly poison. Care should be taken in handling it.

Ink.—Ink stains are very hard to remove because it is impossible to tell what the nature of the ink is. Colored material may be soaked in sour milk. Free chlorine bleaches ink quite readily, and nearly all ink eradicators depend upon this element for removing the color.

On an ink spot apply alternately bleaching powder and dilute solution of hydrochloric or oxalic acid. If the ink spot is old and hard to remove, use a few crystals of fresh stannous chloride, followed by oxalic acid, and wash. The stannous chloride changes

the iron in the ink to a soluble form, and prevents the fading of color in fabric.

Straw Hats.—Dissolve one ounce of salts of lemon in a pint of hot water and add one ounce of flowers of sulphur. Apply with a brush, and rinse thoroughly with water.

WATER SUPPLY

Measurement of Water Supply.—Water is sold to the public by two methods:

1. The flat rate.
2. The thousand gallon method.

If water is purchased by the second method, it must pass through

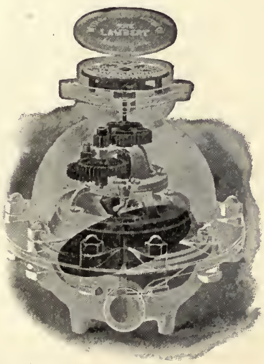


Fig. 170.—X-Ray view of the water meter.

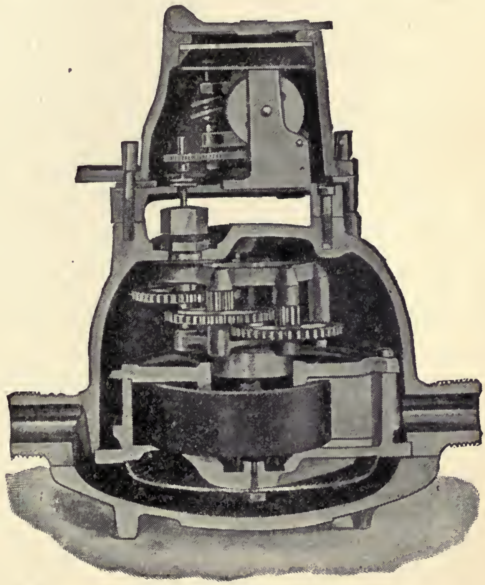


Fig. 171.—Another X-Ray view of the water meter.

a water meter which is located in the supply line from the water main to the consumer's house. These meters are either placed

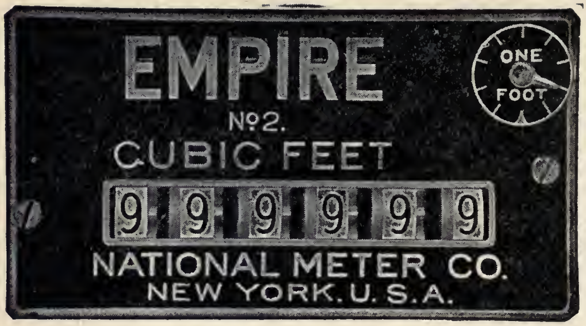


FIG. 172.—Dial of a water meter.

opposite the house or in a man-hole under ground in front of the house.

Accuracy of Meters.— It is very rare that a water meter over-registers. Any disarrangement of the meter from dirt entering the working parts usually slows the meter down and causes it to under-register. There is also a small amount of unavoidable leakage which causes the meter to under-register. Meters register in cubic feet or in gallons. One cubic foot is taken commercially as equal to $7\frac{1}{2}$ gallons.

Determination of the Amount of Water Required for Any Appliance.— One may determine the amount of water required for watering a lawn by turning on the water, and allowing the hose to run one-half hour,

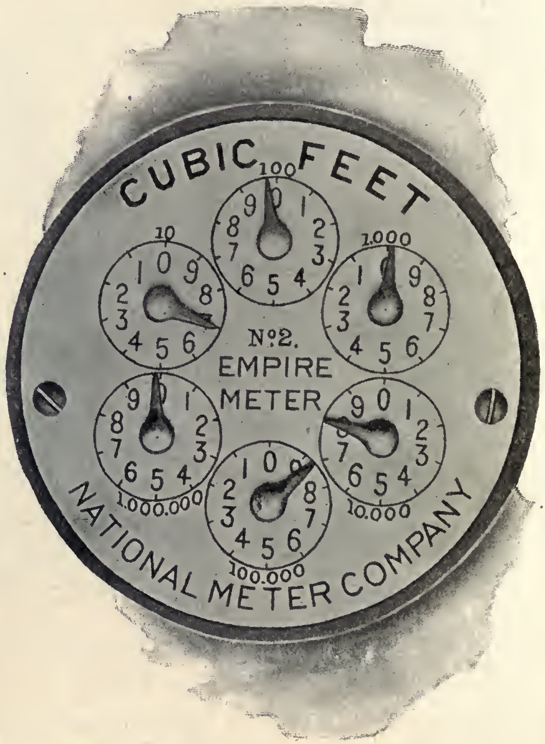


FIG. 173.—Dial of a water meter.

reading the meter at the beginning and at the end of the period, and then subtracting the first reading from the second.

If water is being wasted through some leak, this can be easily detected by observing the hand on the circle marked "1 foot," and computing the amount of water wasted per day or month.

Leaks and Faucets.—Water faucets are provided with replaceable valve discs which occasionally must be renewed because of the

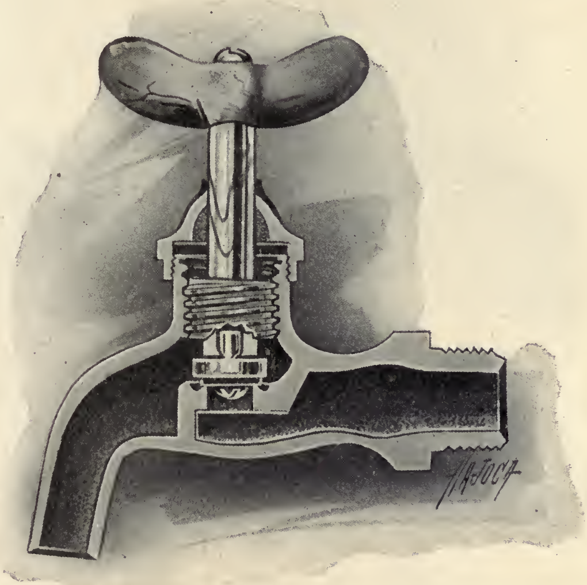


FIG. 174.—What part of this faucet requires renewing occasionally? What allows water to run from the pipe when the screw is turned?

constant wear. When a disc is worn thin, water begins to drip from the faucets—an action which may cause a great deal of waste.

Experiment to Determine the Amount of Water Lost through Faucets Dripping.—Turn on a faucet slightly, and measure the amount of water in pints, quarts or gallons which may run out of the faucet in fifteen minutes. Determine the amount that would run out in twenty-four hours. Determine the amount for a week, month and year. Find the cost of your water supply,

and determine from this the loss for the periods of time mentioned above. Turn on the faucet so that a very slight stream runs. Try several different streams, from slow dripping to a stream the size of a pencil.

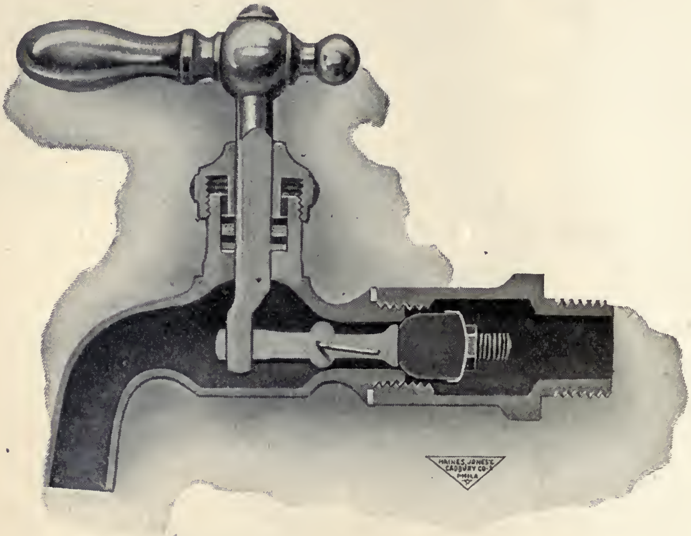


FIG. 175.—What part of this faucet must be renewed whenever there is a leak? What causes the water to run from the pipe?

Sources of Fresh Water.—Fresh water may be obtained from:

1. Rain water.
2. Lakes and rivers.
3. Springs and shallow wells.
4. Artesian wells.

Not all water which looks clear may be considered pure. Shallow wells and springs may often contain surface water which has been contaminated. Sparkling spring water may be very unsafe to drink. Artesian well water, however, is usually pure, since the water comes from such a great depth in the earth that it cannot be affected by animal contamination. Such water usually contains a great many mineral compounds.

Test of Impurities in Water.—Water may be contaminated by:

1. Organic matter.
2. Leaf mold.
3. Vegetable matter.
4. Animal matter. (Sewer contamination.)

Heating Test.—Heat a little water in a corked flask. Do not bring it to boiling point. Shake, remove the stopper, and smell the contents. Pure water is free from odor.

Test for Organic Matter, Animal or Vegetable Matter.—Add to a small amount of water in a test tube a few drops of sulphuric acid. To this add a small amount of potassium permanganate until the water takes on a decided color. Boil. If the water remains the same color, no organic contamination has taken place, but if the water changes to brown, or becomes colorless, there is organic contamination, either animal or vegetable.

Ammonia Test.—To a small amount of water in a test tube add a little Nessler's reagent. A faint yellow tinge only should be visible. A turbid appearance indicates animal contamination and that the water is dangerous to use. All natural water contains a very small amount of ammonia but not enough to cause more than a slight coloration with the above test.

Rain water, although practically pure, contains a considerable amount of ammonia dissolved from the atmosphere.

Lead in Water.—Sometimes water standing for some time in the pipes dissolves the lead from lead pipes. We should always allow the water to run from the faucet or drinking fountain for a short time in the morning to be sure that all the water which has stood in the pipes overnight is removed.

Test for Lead.—Place 100 cubic centimeters of water in a flask, and evaporate water until only $\frac{1}{2}$ of the original volume remains. Add a few drops of potassium bichromate. A yellow precipitate shows the presence of lead. Other metals, such as iron and copper, may be dissolved in spring water. This may be detected by boiling 2 grams of stearic acid in 30 cubic centimeters of water for five minutes. After the water has cooled, examine it before a white background. Iron salts cause the water to have a yellow color. Copper salts will give a bluish appearance.

Hot water from kitchen boilers should never be used for drinking water, since hot water dissolves both the lead and the copper and some of the brass from the boiler and pipes.

Soft Water.—Some waters act on lead pipes, especially soft well waters which contain much dissolved carbonic acid. If a water causes a coating to form on the interior of a lead pipe, there is little or no danger of lead poisoning, because the coating protects the metal; but if the lead stays bright it indicates that the metal is being dissolved, a fact which will make the water dangerous to use.

Common Salt in Water.—Water polluted by the drainage of a house contains a small amount of salt. All water contains some salt, but the amount of salt found in water polluted in this way is greatly increased.

Test for Salt.*—Place 50 cubic centimeters of water in each of two small flasks. Add a few drops of dilute potassium chromate solution. Color the contents of the two flasks as nearly alike as possible. Add to one flask a standard silver solution drop by drop from a pipette showing cubic centimeters. Frequently agitate the glass. The number of cubic centimeters required to produce the first tinge of red in the flask denotes the number of parts of chlorin (salt) in 100,000 parts of water. The slight tinge of red is better seen by comparing the contents of the flask with the contents of the flask to which the silver solution has not been added.

If the water contains more than five parts of chlorin per 100,000, contamination from sewers or sink drains is possible.

Sea coast towns have a large percentage of salt in the water. The percentage of salt in such places may be obtained from the State Board of Health.

A standard silver solution is prepared by dissolving 36 grains (2.3944 grams) of silver nitrate in a liter (1000 cubic centimeters) of distilled water.

Hard and Soft Water.—Water is often called hard if soap suds will not form in it. It is very difficult to clean clothes in hard water. There are two kinds of hardness, (1) temporary hardness, due to calcium bicarbonate which can be removed by boiling the water and causing calcium carbonate to form at the bottom of the dish; (2) permanent hardness, which is caused by sulphates and chlorides of calcium and magnesium. This is called permanent hardness because boiling will not render the water soft. If washing soda or soda ash is added to such water, the effect is to soften it.

Hard water often causes scales to form on the inside of kitchen and factory boilers. This may prove dangerous, since heat is not

* By Allyn.

conducted well through the scales, and the heat of the fire will cause the boilers or pipes to melt, resulting in an explosion when the water suddenly comes in contact with the red hot metal.

Hard water sometimes causes stomach and intestinal troubles. A person accustomed to soft water may be made ill by drinking hard water, and vice versa.

Purification of Water.—Water for many cities and towns is purified by sand filtration. Very fine sand is placed at the top of the filter and coarse sand at the bottom. Water is allowed to run through the sand—an action which removes the impurities and a great many of the bacteria. These filters are washed by forcing water through them in the opposite direction.

Boiling is another method of purifying water. Boiling kills the bacteria but does not remove the impurities. Water may be purified in the home by this process and placed in stone jars to cool. When water is boiled the air is driven out of it. By allowing the water to stand a day or so it will absorb fresh air and again be palatable.

Distilling, still another process for purifying water not only kills the bacteria but removes all impurities, since the water is changed into steam and condensed again to water. Rain water is nature's distilled water. In some countries this water is caught in cisterns and used for drinking water.

House Filter.—House filters for faucets are practically useless. They may be dangerous. The only filter that is worth while is the Pasteur-Chamberlain, made of a baked clay tube surrounded by a metal tube. The pressure filters water through the clay into a receptacle used for storing it. The filter must be washed daily and baked every week in order to remove all unhealthy matter which may have collected.

Drinking Fountains.—There is hardly any excuse to-day for having the common drinking cup in any school or public building. Where drinking fountains are not possible, individual drinking cups may be used.

Many diseases may be carried through common drinking cups.
Figs. 176 to 180 teach valuable lessons about drinking fountains.
Why are common drinking cups and towels dangerous?

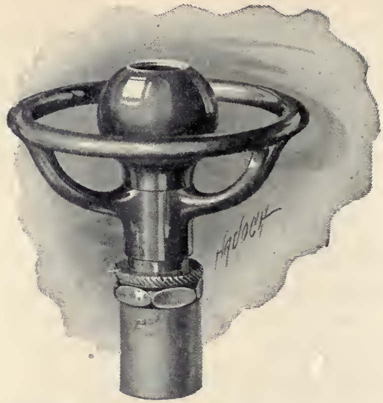


FIG. 176.—A danger always present in this type of drinking fountain is that of breaking the teeth of one child if another playfully pushes him when drinking. This type of drinking fountain may prove to be worse than the common drinking cup. Bacteria will remain in the little bowl and in the water standing in it. Even if the water is allowed to run continually, bacteria and disease germs have been found constantly moving up and down in the water.

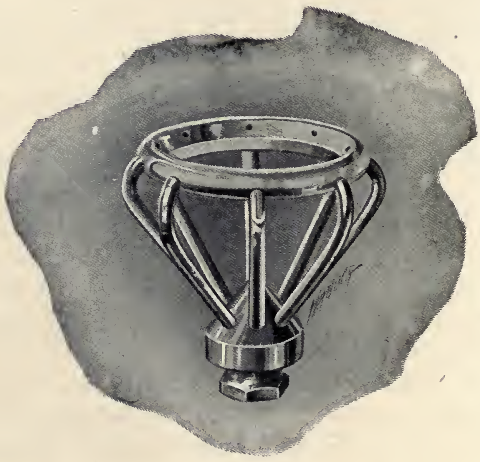


FIG. 177.—This type of drinking fountain prevents the danger of having the teeth broken. A person drinking cannot get his mouth in contact with the metal. There is no bowl for the water to run back in; since the water meets in a spray at the center of the fountain and the excess water falls back into the drain.

Why should the water of a drinking fountain bubble at least two inches above the fixture?

Fig. 178.—This type of drinking fountain is unsatisfactory. The hands may be dirty and dirt may collect about the mouthpiece. The person may touch his or her lips to the metal. Children have been known to put gum, sticks and other dangerous material in the bowl of such a fountain.

Why should the force be sufficient to prevent the lips from touching the cup?

Fig. 179.—A drinking fountain in which the little girl's hands are in the proper place. The water is turned on at a distance from the place where she is to drink. A number of fine sprays meet at a point near the center of the drinking piece. This fountain is clean and sanitary.

Why should the cup be made of material that neither rusts nor corrodes?

What kind of material is best for the fixtures?

Why should the stream of water be steady?

Why should the discharge for waste water be large?

Why should a drinking fountain close automatically?

Where should drinking fountains be located? Why?

What is the law in your state regarding drinking fountains and drinking cups?

What diseases do you think could be carried by common drinking cups?

Why are a number of small sprays meeting at a point better than a large stream bubbling up?

Why should the hands be as far away from the mouth as possible?

Fig. 180.—A drinking fountain for keeping water cool.

Cisterns. — Cisterns for storage of water should be so constructed as to be inspected and cleaned occasionally. They should be made of brick or wood, lined with tin or cement, and provided with an overflow pipe for allowing the excess water to run into a drain.

Wells.—It is necessary to keep wells closely covered and provided with a stratum of earth sloping away from the mouth of the well, since ground water is liable to run into the well and cause pollution. The boards covering the well should be tightly fitted

together so as not to allow any cracks, thus preventing the entrance of filth and other contamination.

Toads, moles, or insects are liable to tunnel through the cool moist soil by the well and fall into the water, in this way producing contamination. One should be careful of the location of cesspools, barnyards, hen-houses and outhouses, that no water draining from

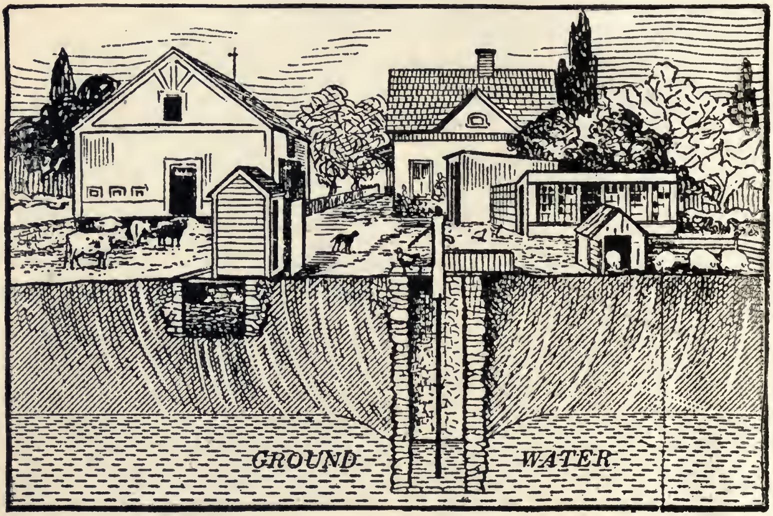


FIG. 181.—Why is a well of this type dangerous? What diseases do you think people might get from drinking the water? Where would be a better place for the well?

these places may lead toward the well without filtering through a great deal of soil. Wells should be cleaned often.

Rivers and Streams.—Great care should be taken by all health authorities that no impure matter is placed near streams or lakes from which water is being used for drinking purposes. Epidemics of typhoid fever have often been started by the draining of water into such streams or lakes from places which have been polluted. Lakes and ponds, which are quiet waters with large surfaces exposed to the light, may become purified by the suspended matter settling,

but one cannot be absolutely sure that the water is free from contamination.

Sewer Gas.—There is not as much danger in sewer gas as is sometimes supposed, since analysis of the gas shows that it is often freer from germs than is street air. Sewer gas, however, is very unpleasant to have in the house. Therefore vents must be so constructed as to allow all gases to pass through the house without entering any of the rooms. Fig. 187 shows the arrangement for allowing the sewer gas to escape by means of a soil stack

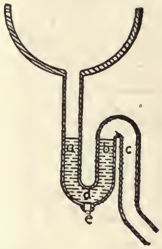


FIG. 182.—A hand basin and water trap. Why is material collected at *d*? Why is there a nut at *e*?

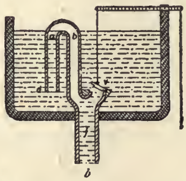


FIG. 183.—A tank for flushing a closet. By pulling the string the trap is opened, causing water to run down the pipe *f*. This causes a partial vacuum at *b*, since some of the air will go out with the water. Water rises in *a*, flowing into *b* it produces a siphon as soon as the trap is closed.

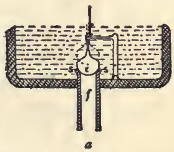


FIG. 184.—Another type of tank for flushing a closet. The bulb at *ss* is pulled up, allowing water to run down the pipe *f*.

or vent stack through the roof. The soil pipe passes from the sloping drain pipe up through the house and extends above the roof.

Traps.—Traps must be provided for all fixtures which are attached to drain pipes. The bent part of the pipe is called a trap. A small amount of water must remain in this in order to prevent gases from passing into the house.

Peppermint Test.—Sometimes sewer gas without odor enters the house because the soil pipes are not perfectly sound. If there is any suspicion of this, a very simple test may be made by pouring two ounces of peppermint, followed by a pail of hot water, down the

soil pipe through the opening in the roof. If all the joints leading to the drain pipes are not perfect, the odor of peppermint will be detected in the house. The soil pipe should be covered for test.

Fixtures in the House.—Fixtures for the water supply in the house should be made of enameled iron or porcelain. They must

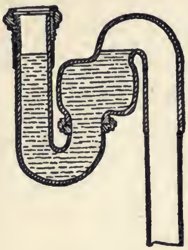


Fig. 185.—A water trap. Why does the water prevent sewer gas entering the house?

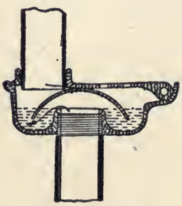


Fig. 186.—A water trap for a refrigerator.

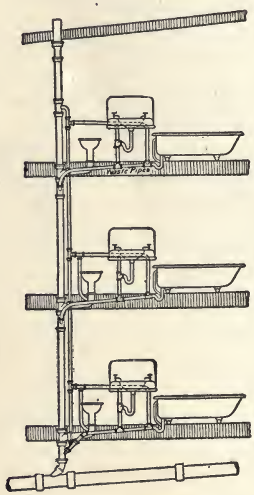


Fig. 187.—Why is it necessary to have a vent stack through the roof? Why is each fixture furnished with water trap?

be easy to clean, and all parts easily accessible. Hydrochloric acid may be used as a disinfectant and remover of stains from hard water.

Facts to be Remembered.

1. Pure water is a luxury.
2. Pure water is a necessity.
3. Pure water is cheap.

4. Impure water is dangerous.
5. Impure water is expensive.
6. Ground-waters must be protected.
7. Surface-waters must be purified.
8. Qualities to be sought in water—wholesomeness, cleanliness and softness.
9. Filtration makes water clean.
10. Filtration makes water safe.
11. Filtration has been justified by experience.
12. Hard water may be softened.

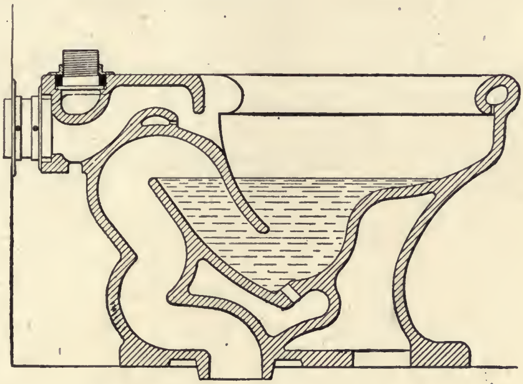


FIG. 188.—A closet showing trap.

QUESTIONS

1. What is the most dangerous source of water pollution? Why?
2. What objections can be given to the use of hard water? Soft water?
3. Why should water from the hot water boiler never be used for drinking water?
4. What precautions must be taken if water is obtained through lead pipes?
5. If you get a drink early in the morning at a drinking fountain what should you do first?
6. Give two reasons why the lips and the teeth should never touch any part of the fountain.

7. How could a drinking fountain be constructed so as to avoid the danger of having the teeth broken if some one accidentally hit a person while drinking?

8. Examine the fountains in your building to see if this has been provided for.

9. Why is placing ice from ponds in drinking water objectionable?

10. What care should be taken of wells? Of cisterns?

11. Locate several wells you know of, and tell whether they are properly or improperly located?

12. Why are fire hydrants necessary in cities?

13. Where is the hydrant nearest to your home?

14. What would you do in case of fire?

15. Why is it necessary to attach fire engines to hydrants?

16. What provision has been made in your home against sewer gas?

17. How would you be able to test the drain pipes of your home for sewer gas?

CHAPTER IX

GERMS AND DISEASE

GERMS

Protozoa are one-celled animals of microscopic size. The one cell performs all the functions necessary for the life of the protozoon.

They look very often like a tiny mass of clear jelly. In fact, they are the smallest of all animals. Some can be barely seen with the naked eye, others are so small as to look like tiny specks under the most powerful microscope.

Protozoa live abundantly in water, but they also grow in the bodies of men and animals, causing some of the worst germ diseases known.

Bacteria are minute one-celled plants visible only through the compound microscope. They are found everywhere, in the air, water, and soil, as well as in the bodies of living animals and plants, and in products obtained from them.

Bacteria cause decay, sometimes a fermentation, and cause many diseases of plants and animals. Other names for bacteria are **germs** or **microbes.** Useful bacteria cause decay of dead matter which can then be used by growing plants. In the preparation of vinegar, cheese and butter, bacteria are necessary. Food for certain plants can be produced only by bacteria in the soil.

Many bacteria are harmless, but there are about twenty which are capable of producing disease in man.

There are two classes of bacteria:

1. **Saprophyte,** a micro-organism which derives its food from decaying animal or vegetable matter. Examples are: mushrooms, and mold on bread or cheese.

2. **Parasite,** an organism which inhabits another organism. For example, nearly all of the disease-producing bacteria are parasites.

Shape.—There are three forms of bacteria: the rod, the sphere, and the spiral.

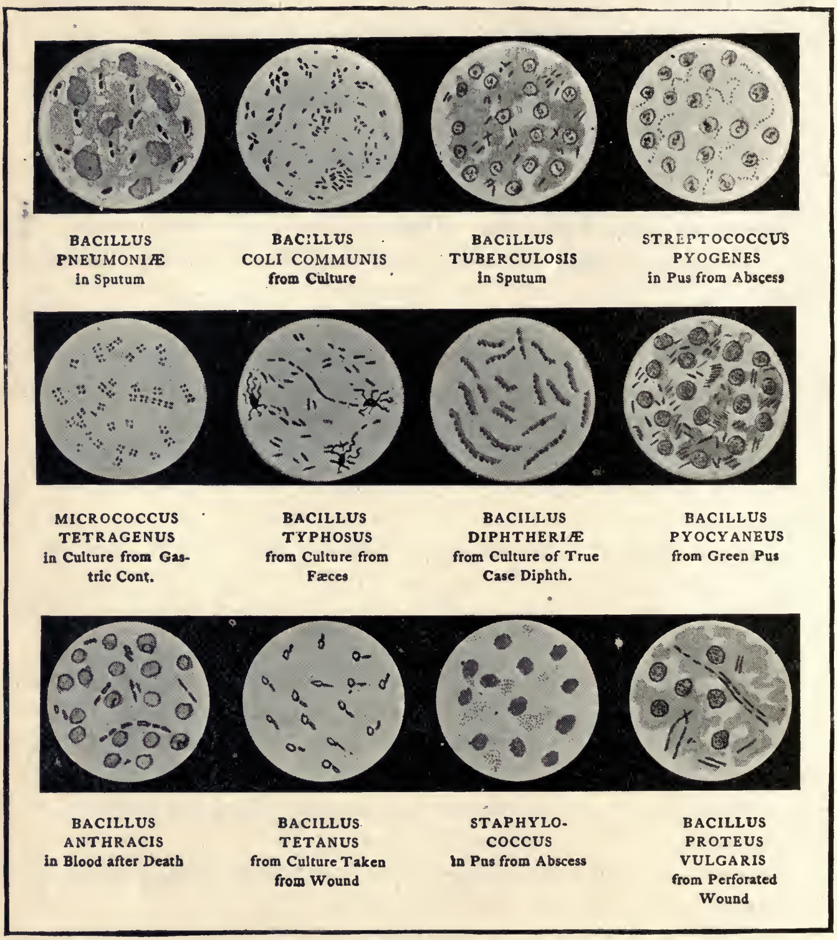


FIG. 189.

Motion.—Bacteria have motion, due to the presence of hairlike appendages called **flagella** which, by a lashing movement, enable them to move through fluids.

Spores.—Following a favorable period of reproduction, certain bacteria enter into a stage known as **spore-formation,** a single cell usually producing one spore. This is a resting stage. The spores are of dense structure, and offer extraordinary resistance to heat, chemicals and disinfectants. When conditions again are favorable, the spores again enter the reproductive state, but the spore may remain dormant for an indefinite time, as in the case of a typhoid patient, who, after months or years, suffers a recurrence of the disease, due to the development of sleeping spores.

Multiplication of Germs.—When germs have fully developed, a fission takes place which divides the cell into two equal parts. These in turn divide into two parts each. As the fission occurs rapidly, sometimes as often as once in 20 minutes, the multiplication is enormous, sometimes amounting to millions in a day.

How Germs Enter the Body.—Germs may be introduced into the body through:

1. The sweat glands.
2. The hair follicles.
3. The mucous membrane (nose and mouth).
4. Abrasions in the skin.
5. Drinking polluted water or milk.
6. Eating food that contains germs, or has had germs deposited upon it by flies.
7. Mosquitoes and other insects which carry different disease germs to the body.

How Germs Cause Disease.—Germs produce **virulent** (vir′u lent) **poisons** as they grow in the body. These poisons cause **toxins.** It is the toxins that cause disease, not the germs.

How the Body Kills Germs.—The little white corpuscles of the blood are useful animals. One of their functions in the blood is to kill disease germs by eating them. Sometimes the corpuscles, after swallowing the germs, are unable to digest them, and are killed by them. If this happens, the disease will become worse, and if it continues, the patient will die. If the corpuscles are strong enough to digest the germs, the person usually gets well. There is also a substance which kills germs. Every healthy person has a sufficient quantity of this substance in his body to kill some germs, but not

sufficient to overcome a great attack of germs. When disease germs enter the blood and begin to multiply very rapidly, more of this **germicidal substance** is manufactured, and it assists the corpuscles in killing the germs. **The turn of a fever** comes at the time when the corpuscles and germicidal substance get the upper hand of the germs.

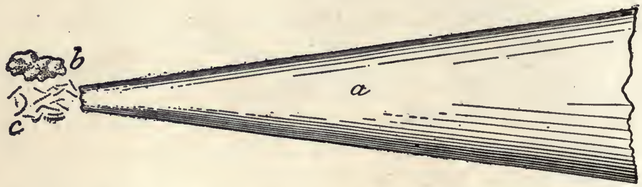


FIG. 189*a*.—Comparative size. *a*, End of a lead pencil. *b*, A dust particle. *c*, Bacteria.
Conn.

There is a different type of germicidal substance for every disease germ. Sometimes this germicidal substance remains in the blood for a long time after the person has recovered from the disease. Therefore, that person can never have that particular disease as long as the germicidal substance is present in the blood. Germicidal substances which destroy cold-producing bacteria remain in the body so short a time that a person can "catch cold" again within a few hours after getting rid of one.

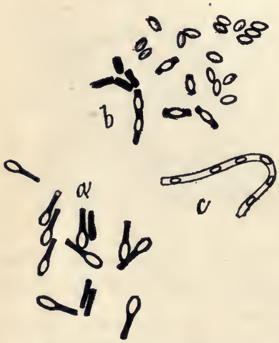
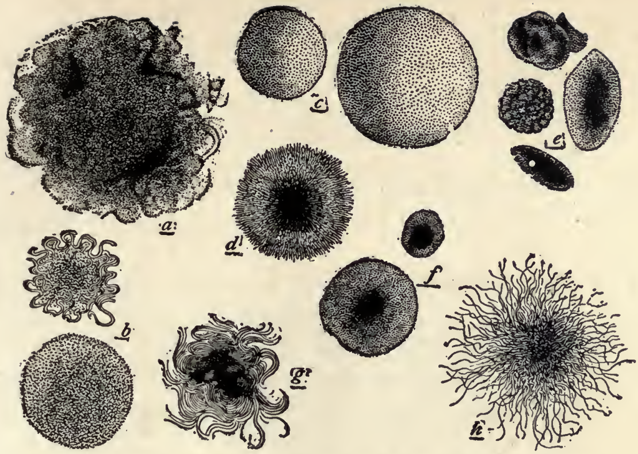
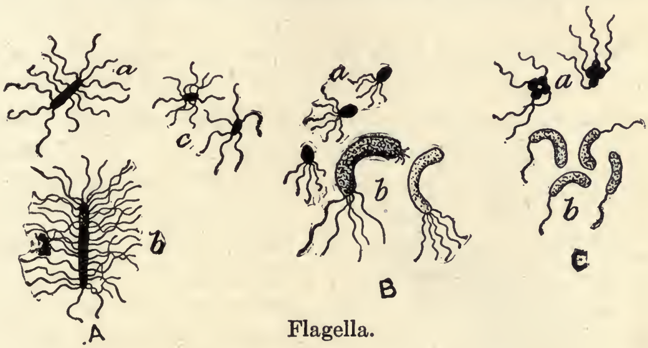


FIG. 189*b*.—Spore formation.
Conn.

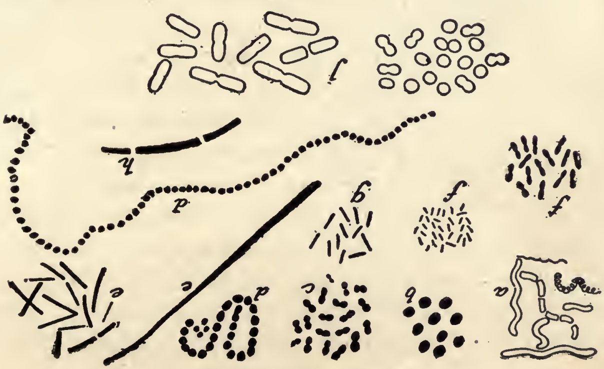
Diseases Are Not Inherited.—Diseases are not inherited. The only thing that is inherited is the power of killing the germs of any disease. For example: If the parents of any child have little power to kill germs of consumption, leprosy, or cancer, the child will inherit the tendency to have little power of killing the germs. Certain races have little power of killing the bacteria of leprosy and consumption. It is believed that people who drink alcohol lower the ability of the blood to produce germicidal substances for killing bacteria.



Various types of colonies of bacteria growing in gelatine.



Flagella.



Shapes of bacteria. *Conn.*

Questions

1. What is the meaning of the word "germ"?
2. Why should you be careful about putting your fingers in your mouth or nose?
3. How do germs cause disease in the body?
4. What would happen if the white corpuscles of the blood were removed?
5. Why does a doctor know that a person will get well if a fever "turns"?
6. Why is it wrong to say that people inherit disease?
7. Why does a drinking man have less chance of getting well from a severe illness?

DISEASES CAUSED BY PROTOZOA

Malaria.—Malaria is caused by protozoa that live in the little red corpuscles of the blood. They are injected into the body by a kind of mosquito called the **anopheles.** The diagram will show how very different it is from the **culex** or **common mosquito.** **Malarial mosquitoes** do not travel very far from the place where they live. The wind often blows the ordinary mosquito great distances, but the anopheles mosquito has the habit of clinging to bushes, shrubs and weeds near the place where it hatches.

Fig. 190.—The malarial mosquito.
Courtesy of Am. Mus. Nat. Hist.

The mosquito inserts its proboscis through the skin of a human being, and sucks out the blood. In order to remove the blood from a person, the mosquito must dissolve the little red corpuscles, since they are too large to pass through the opening in its proboscis. Hence the mosquito

injects saliva into the blood to break up and digest the red corpuscles. If the mosquito is infected with malaria, it will inject into the blood at the same time malarial germs which will attack the red corpuscles and begin to grow in them. They grow very rapidly and soon break the corpuscles open, liberating a great quantity of toxin. When this toxin enters the blood from the red corpuscle, it causes chills.

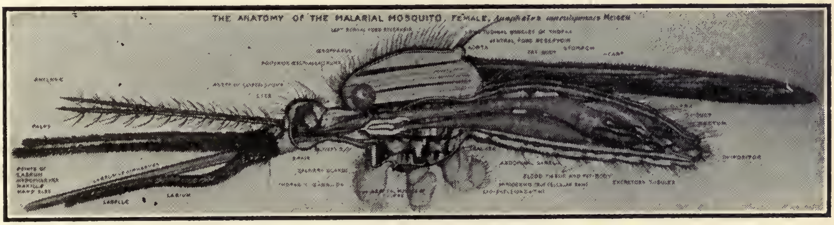


FIG. 191.

Courtesy of Am. Mus. Nat. Hist.

Methods of Preventing Malaria.—Quinine is sometimes used to kill malaria germs. Small doses are given daily to the patient. The quinine enters the blood and kills the malaria protozoa when it leaves the red corpuscle.

People living in malaria-infected districts should carefully screen their houses and destroy all places where mosquitoes can breed, such as tin cans, old barrels, and small pools of stagnant water.

Destroying the Mosquitoes.—The mosquito lays its eggs on water. In about a day these hatch into wigglers. These wigglers feed on small one-celled animals that are in the water. They need air to breathe. Hence they come to the surface of the water and thrust out to the air a breathing tube. If the water is covered with oil, they are unable to get this breathing tube through the tough film of oil, and must suffocate.

It takes from fourteen to seventeen days for the mosquito to reach the "tumbler" stage, so called because instead of wiggling as it swims, it turns over and over. In from ten to twenty days after the egg is laid, the tumbler splits down the back, and the mosquito comes out and flies away.

Smallpox.—Smallpox was, until the discovery of vaccination, one of the most dreaded diseases on account of its loathsome appearance, extreme contagiousness and disfiguring consequences. Until a little more than a century ago the disease was a great scourge, for it attacked nearly every one, the loss of life being enormous. At one time a large percentage of people in England were pock-marked. Smallpox was the most common cause of blindness. Instead of occurring in epidemics, as now, the disease was present continuously.

Smallpox is usually transferred from one person to another through the air, but it may be carried by infected clothing and other objects. The extreme contagiousness of this disease is due to the longevity of the germ. A person suffering from smallpox must be strictly quarantined and everything that has been about him burned or disinfected.

Vaccination.—Dr. Edward Jenner of Berkeley, England, discovered the principle of vaccination in 1798.

The germs of smallpox grown in cattle cause a disease called cowpox. After growing in the cow the germ is changed and weakened so that it grows feebly in man, and has only a slight power of producing disease. In vaccination the germs from an infected cow are injected into the human body, where they grow and produce the usual condition following vaccination. The body works up the germicidal substance necessary to kill germs before they make much progress in the body. After this the germicidal substance remains in the blood ready to kill any smallpox germs which may enter the body. This germicidal substance grows weaker and weaker, and after a few years re-vaccination may be necessary for full protection from the disease. The safest way is to be vaccinated every few years. If the germicidal substance is still strong in the blood, the vaccination will not "take." Two successful vaccinations usually protect against smallpox for life. Doctors, nurses, and attendants, if successfully vaccinated, have lived in smallpox hospitals in perfect safety.

Practically all the accidents of vaccination can be prevented by the selection of the proper vaccine and suitable care of the arm after vaccination. The danger from vaccination has been greatly exaggerated. It is indeed slight as compared with the danger of

remaining unvaccinated. Vaccination is compulsory in the army and navy, and, in most instances, for the civil population.

Care of Vaccination Wounds.—Like any other wound, a vaccination wound may become infected with various germs if not kept perfectly clean. Apply a half dozen layers of sterile gauze held on the arm by strips of adhesive plaster. Apply this shortly after vaccination and keep it on constantly, changing the gauze with clean hands every few days.

Avoid bruising or injuring the arm. In case the gauze sticks to the wound, loosen it with a hot 2 per cent solution of carbolic acid in water. If vaccination is followed by illness or excessive inflammation in the arm, a physician should be consulted. When bathing do not allow the gauze to become wet.

Another good method of treating the vaccination wound is to begin forty-eight hours after vaccination to paint over and around the wound a 2 per cent solution of picric acid in 70 per cent alcohol. Continue this daily until the crust becomes quite hard. (Tenth to fifteenth day.) After this apply carbolized vaseline. After painting the wound, cover with gauze in the usual way.

Rabies (Hydrophobia).—Rabies is believed to be caused by a protozoon growing in the nerve tissue. It may attack animals as well as man. The germ is found in the saliva of affected animals, entering the human system through their bites. Most cases in this country come from the bites of dogs. In man the germ grows slowly, requiring at least two weeks before the disease shows itself, while the period of development may extend to any time within a year after the bite.

For this disease, Louis Pasteur, a French scientist, discovered a preventative treatment which is usually successful if commenced in time. No time should be lost in beginning this treatment, for there is no cure for rabies after the development of the disease. If the materials for this treatment can be procured, the home physician may administer the treatment.

Any dog bite should be promptly treated with the best disinfectant at hand. Burning the wound with nitric acid is the most effective remedy.

Questions

1. Why are not all mosquitoes dangerous?

2. How are you able to tell the difference between the mosquito which causes malaria and the mosquito which is harmless?

3. What methods should be used to prevent mosquitoes from breeding and carrying disease?

4. Why has vaccination practically exterminated smallpox?

5. Why is it wrong to say that hot weather causes dogs to have rabies?

6. Why should a dog who has bitten a person be confined for nine or ten days?

7. What should be done immediately to a person who has been bitten by a dog?

DISEASES CAUSED BY BACTERIA

Colds.—A "cold" is not a proper name for the disease which we call the "common cold" for the simple reason that effects of cold or any other outside influence alone are powerless to produce the condition known by that name. Arctic explorers who go into a region where it is impossible for germs to live never have colds due to exposure to cold winds. They may have a great deal of mucus from the membrane of the nose and throat, but they do not suffer from pains in the back and joints, and other general discomforts which the "cold" brings to us. It is also known concerning Arctic explorers who make a long stay in regions where there are few bacteria, that the secretions of the mucous membrane gradually lose their germicidal power to kill the bacteria of "cold," so that on their return to more temperate latitudes, consequently to places where there are many germs, they suffer severely from attacks of "colds" or catarrh. The bacteria which produce "colds" live continually in the mucous membrane. There is always flowing from the mucous membrane a secretion of mucus, the function of which is to protect the body. The air passing from outside must pass through this mucus. For this reason the dust particles of the air, bearing bacteria, mold, etc., are deposited on the walls of the respiratory passages, so that under normal condtions but little dust and few bacteria reach the lungs.

How We Catch a Cold.—Because of the germicidal properties of the mucus, the bacteria which are constantly living in the body are unable to do any injury or produce disease until the body condition is altered or weakened so that the bacteria may live. There are two ways of catching cold; first, when the bacteria in the mucus of the nasal passages or pharynx become sufficiently active to cause inflammation; second, when additional bacteria come from the outside. The bacteria immediately begin to multiply and soon attack the mucous membrane. The first result is a large secretion of mucus which represents nature's method of destroying or washing out the bacteria. This mucous secretion is deficient in bactericidal properties and only furnishes a better breeding ground for the bacteria; first we see a thin watery discharge from the nose which, as the bacteria multiply, becomes gradually more and more tenacious and finally assumes a yellowish color. The toxin which is produced by the germs enters the blood, producing backache, pains in the joints, and general feeling of illness. The body at once starts to manufacture germicidal substances to kill the bacteria and neutralize the toxins; hence the person recovers from a cold.

It will be seen that colds are contagious, and may be obtained from people in assemblies, school rooms, street and railway cars, through the use of the common drinking cup and even from the drinking fountain.

The mucus-secreting apparatus has several definite purposes: (1) As a covering film to protect the membranes from the effects of extremely cold air; (2) to aid in warming the air sufficiently before it is passed on to the lungs; (3) to gather from the air bacteria and other impurities; (4) as a germicidal power to destroy bacteria which enter the mucus.

Diphtheria.—Diphtheria germs are usually found in the larynx and mouth. These germs live in material which has come from the throat of a diphtheria patient. A slight attack of diphtheria often causes sore throat only, but if the germs grow rapidly the attack is so severe that death follows in a few days. The germ may cause death by closing the throat, but, as a rule, death is caused by the powerful toxin which the germ produces. The

poison is so powerful that it stops the action of the heart. Just as soon as the germ enters the body, the body tries to produce a substance which will neutralize the toxin. This substance is called anti-toxin, "anti" meaning "against." The anti-toxin does not kill the germ, but simply destroys the toxin poison which the germ has produced.

Use of Anti-Toxin.—Anti-toxin is rapidly produced in the horse. Because of this fact, diphtheria germs are grown in beef broth where they produce a great amount of toxin. This toxin is injected into the blood of the horse which produces large quantities of anti-toxin to neutralize the toxin poison. The horse is then bled, and the anti-toxin purified and placed in bottles. It may now be injected into people who are suffering from a severe attack of diphtheria.

Pneumonia.—In the colder parts of our country this disease causes more deaths than any other. The germicidal substance which is worked up by the body to kill the pneumonia germ stays in the blood only a short time, and the patient may have a relapse before completely recovering from the disease. A person may also have the disease again and again.

The germ can not be entirely avoided, but anything that builds up the general health is a safeguard against pneumonia. Anything that weakens the body may bring on the disease, for the germ may be in the throat waiting for something to lower the germicidal power of the body. The sputum from pneumonia patients should be destroyed.

Influenza (grip), catarrh and colds are caused by germs, and may be transferred from one person to another.

Typhoid Fever.—This disease has caused one-fifth of the world's mortality. We contract typhoid fever by taking the germ into the body through the mouth, usually in water or food. Moss-covered buckets, stagnant pools and wells are breeding places for typhoid germs. We find the germ also in oysters not strictly fresh, contaminated raw fruit, and polluted milk.

The typhoid germ dies from drying and is not carried about in the air. The excretions from typhoid patients contain millions of germs, great numbers of which will be carried by flies if all excretions are not destroyed.

Prevention of Typhoid Fever.—The disease is practically overcome by inoculation with dead bacteria. The way of preventing typhoid fever is somewhat different from that of smallpox, for which living weakened organisms are introduced into the system through vaccination. Typhoid fever bacteria are developed in a bouillon culture by adding live bacteria to the bouillon. After they have sufficiently developed they are killed by heating the culture to 140° F. for an hour. The solution must not be overheated.

The preventive treatment is divided into three injections:

1. An injection of 500,000,000 bacteria in a cubic centimeter of about one teaspoonful salt water solution (made by adding a teaspoonful of salt to a pint of water). This treatment is given about the middle part of the afternoon because reactions from the treatment, if any, appear about bedtime. Rarely, nausea, vomiting, headaches, and a rise in temperature develop. As a rule there is only a slight headache, a feeling of drowsiness, and a tender area around the point of inoculation. All these symptoms are gone by morning, and the patient is as healthy as usual.

2. A dose of 1,000,000,000 bacteria in one cubic centimeter of salt water solution is given ten days later.

3. Twenty days later another dose of the same number of bacilli is injected. Usually no discomfort is felt from these last injections.

Immunity from typhoid fever produced by the inoculation of the dead bacteria lasts about two years. Since this method of combating the disease has been used in the army, typhoid fever has practically disappeared there.

The Fly.—The common house fly has received the name of **typhoid fly** because it is the means by which the typhoid germ may travel from infected material to foods which people are about to eat. This fly has been known to carry 6,600,000 germs on it at one time. A fly which carries only 1000 germs may be considered clean.

Flies breed in filthy places. One fly has been known to lay one hundred and twenty (120) eggs in fourteen hours. It takes ten or twelve days for an egg to develop. This means that a dozen generations can be produced in a single season. During one season one

fly may be the progenitor of 195,312,500,000 flies, or about one hundred and ninety-five thousand bushels, if none of the flies are destroyed. This shows the necessity of destroying the fly whenever it is possible.

Flies travel from decayed matter in which there are typhoid germs, and carry them to milk which is to be used for children. A fly may alight on sputum on the sidewalk, or it may come directly from some filthy place to the table where food is about to be served. People should screen their houses and use fly traps. Garbage

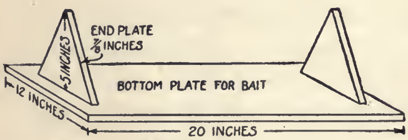


FIG. 192*a*.

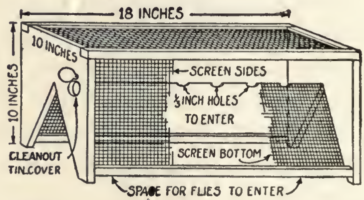


FIG. 192*b*.—A very successful fly trap.

should be well covered. Also, for the sake of health, people should avoid expectorating in public places.

It takes about 6000 flies to weigh an ounce.

Build a fly trap and see how many flies you are able to destroy in one season.

Using fly paper is a good way to destroy flies, as germs as well as flies are caught. Pyrethrum powder burned in a house stupefies flies until they may be swept up. Twenty drops of carbolic acid on a hot shovel create a vapor that kills flies. Common mignonette plant seems to prevent flies from living in the room where it is growing. A cheap manufactured poison not dangerous to human life is bichromate of potassium in solution. One dram, dissolved in two ounces of sweetened water and placed in a shallow dish, will kill a great many flies. A spoonful of formaldehyde in a quarter of a pint of water will dispose of a great many. Cleanliness prevents flies from breeding.

Flies may carry diseases many miles. They have been known to travel from New York to Maine in a sleeping car.

For the Good of Your Community.—Check up your yard and your neighbors' yards for the following things:

1. Manure pile.
2. Garbage.
3. Tin cans.
4. Ashes.
5. Weeds.
6. Full privy vaults.
7. Tumble-down shed.
8. Old lumber and rubbish.
9. Dirty chicken- or barn-yard.
10. Neglected well.
11. Uncovered rain barrel or bucket.
12. Tumble-down fence.

Are all conditions satisfactory? Do you find a backyard flower garden or a vegetable garden?

Remarks.

Tuberculosis.—Tuberculosis kills more people than any other disease. Every three minutes, on an average, someone in the United States dies from consumption, and every seventh person who dies, dies from this disease.

Source and Origin.—The **bacillus** of tuberculosis may grow in any part of the body, and cause tuberculosis of the part affected. It is slow-growing, but it has great power of resistance against efforts of the body to kill it. The bacillus does not grow outside of the bodies of men and animals, and is not found away from their habitations.

Tuberculosis of the lungs, which is the most common form, is often called **consumption.** It is caused by the growth and multiplication in the lungs of the very small **tubercle bacillus.** If not checked, these germs spread through one or both lungs and destroy their usefulness, and the patient dies from the disease.

Tuberculosis germs are present everywhere. Everyone breathes in some of these germs at one time or another. If the resistant power of the body against these germs has been weakened from any of the following causes:

1. Insufficient food,
2. Living in dark, ill-ventilated rooms,
3. Poor working conditions,
4. Over-work,
5. Weakened condition following severe illness:

the person may be unable to throw off these germs and will contract tuberculosis.

Prevention.—Good health is the best preventive of tuberculosis. To acquire good health we must have plenty of fresh air all the time, eat good food, observe all rules for cleanliness, and be temperate in personal habits. Avoid breathing dust whenever possible. Never put objects of any kind in the mouth. Do not indulge in intoxicants of any kind.

How Contracted.—We may contract tuberculosis either from the milk of diseased cattle or from the sputum of a consumptive. Sneezing and coughing cause many germs to enter the air. The sputum must never be allowed to dry, as the germs will then enter the air and live for a long time. Spitting in public places should be prohibited. Germ-laden sputum must be destroyed by burning or disinfection. A consumptive person should sleep alone, and, if possible, have a room to himself. It is not dangerous to live or work with a tubercular person if proper care is taken of the sputum.

Symptoms.—The most common symptoms of tuberculosis are cough, loss of appetite, gradual loss of flesh and strength, fever, night sweats, and blood spitting. A person who suspects that he has contracted the disease should be examined by a reliable physician. If the germs have gained a foothold in his lungs, he should immediately give himself the best treatment possible, as tuberculosis, if taken in time, is a curable disease.

Treatment.—The essential factors in the treatment of tuberculosis are:

1. Rest

   Avoid over-work,
   Sleep a great deal,
   Do not take violent exercise.

2. Proper food:
   Eat three nourishing meals a day,
   Drink pure milk between meals.

3. Outdoor air:
   Sleep out of doors,
   Remain in the open air as much as possible.

No medicine is necessary for the cure of tuberculosis. All advertised "**Cures**" are frauds.

There are many sanitariums where a consumptive can have proper food and care at less expense than at home, and where there is proper disinfection against the spread of the disease. The Board of Health of any city will furnish accurate and detailed information for the prevention and cure of this disease.

Questions

1. Why should all material which comes from the throat of a diphtheria patient be destroyed?

2. Why is anti-toxin used, since it does not kill the germs of diphtheria?

3. What kills the diphtheria germs in the body?

4. What causes colds, pneumonia, and grip?

5. If germs cause this disease, why do people say they "catch cold" by sitting in a draft?

6. What care should be taken with food and drinking water in order to prevent typhoid fever?

7. What is the best treatment for typhoid fever?

8. Why should flies be destroyed?

9. Why does the presence of flies denote that there is dirt or filth near by?

10. What value have screens in preventing disease?

11. Why should all table refuse be burned or treated with borax?

12. What relation to the house-fly has a leak in the sewage system?

13. What particular care should be taken with garbage receptacles?

14. Why should flies be kept out of a room where a person is ill with a contagious disease?

Write to the American Medical Association for Booklet on the House Fly.

15. Why should horse manure be treated with borax?

16. How far may flies carry disease?

17. What is the best way to treat consumption?

18. When is it not dangerous to live or work with a tubercular person?

19. When is it dangerous to live or work with a tubercular person?

OTHER DISEASES CAUSED BY BACTERIA

Measles.—Measles is a very serious, infectious disease, not only because bronchitis, pneumonia, and tuberculosis may follow the attack, but because permanent injury may be done the kidneys, ears, eyes, etc.

How Contracted.—The germs spread in the watery matter which runs from a patient's nose, and in the sputum. Whenever a person sneezes or coughs or talks, he throws out tiny drops from the mouth into the air. Anyone entering the room or approaching the patient may catch the disease. Measles has been contracted from milk, by shaking hands with one who has measles, or by coming in contact with the towels, cups, spoons, or any other dishes used by measles patients.

The germs do not live long after they leave the body—a fact which, of course, assists in reducing the chances of spreading the disease.

After Effects.—Soon after recovering from the attack, children may have: 1. weak eyes; 2. bronchitis; 3. broncho-pneumonia; 4. tuberculosis; 5. laryngitis; 6. stomatitis; 7. noma; 8. indigestion; 9. meningitis; 10. diseases of the middle ear.

Long after an attack of measles a person may have: 1. chronic kidney trouble; 2. arterio-sclerosis; 3. nervous trouble.

Preventing the Spreading of Measles.—People leaving the home should not visit the room where the patient is sick. Sterilize dishes and clothes by boiling or placing them in a 5 per cent solution of carbolic acid.

Project.—Write to American Medical Association for information on Measles. Report.

Scarlet Fever.—Scarlet fever must be considered serious even if the patient recovers, because it is liable to cause permanent injury to the ear, heart and kidneys.

Sources.—Scarlet fever germs are given off by the skin, and by discharges of the kidneys and bowels. Since the germs are in the secretions of the throat, mouth, and nose, the patient will throw them into the air with the tiny drops of moisture when he talks, sneezes or coughs. Letters written from the home may carry the malady. Scarlet fever germs may remain alive for months and even years, if protected from air and light. Paper, clothing, letters, bedding, etc., if put away without disinfecting, may be a source of scarlet fever. The milk supply has frequently caused epidemics of scarlet fever.

Project.—Write American Medical Association for information on Scarlet Fever.

Tetanus.—The tetanus bacillus is found in the soil. The dust in the streets, the dirt in our gardens and yards, and particularly the soil around stables contains this germ. It affects horse and man chiefly, entering the body through even very slight wounds. The tetanus germ by itself cannot develop if exposed to the air, but, in combination with other germs, it will grow in an open wound.

Wounds caused by anything that has been in contact with the soil, as a sickle, are most likely to develop tetanus; and small but deep wounds, like those caused by rusty nails, make good breeding places for the germ.

Ptomaine Poisoning.—Bacteria throw off waste matter in substances in which they live. Sometimes this material is very poisonous to human beings. **Ptomaine poisoning** is a disease caused by eating fruit, beef, fish and other things in which bacteria have lived and thrown off this poisonous material.

Blood Poisoning (Septicæmia).—Blood poisoning is brought about by certain classes of bacteria which are present about us everywhere. They may be found in dirt under our nails, in clothing, and on utensils which may be used about the home. Wherever there is dirt the bacteria of blood poisoning are usually present. They are found in food; but people taking such bacteria into the system do not suffer from blood poisoning, since there are in the stomach,

intestines and blood, bacteria in sufficient quantity friendly to the human system and enemies of foreign bacteria.

Blood-poisoning bacteria are usually found in infected wounds, the severity of the poisoning depending upon the point of infection and the character of the tissues.

The white corpuscles or leucocytes (lū kō sīts) of the blood are enemies of all blood-poisoning bacteria. Whether or not a person has a severe case of blood poisoning depends entirely upon the fighting power of the white corpuscles of the blood, which **Metchnikoff** calls "the policemen or scavengers of the circulation." The fighting ability of the white corpuscles depends upon the quantity of a certain substance called **opsonin,** which nourishes them and gives them an increased power of killing harmful bacteria.

Opsonic Index.—Since the fighting power of a white corpuscle depends upon the amount of opsonin present in the blood, the **opsonic index** is taken to determine the fighting power of the white corpuscle which makes a person immune to disease. This is done with a microscope.

Blood is taken from a person and washed with a weak solution of acetic acid to remove the red corpuscles. The white corpuscles are then observed. If one white corpuscle devours about one bacterium, the opsonic index is considered about $\frac{1}{10}$ of 1 per cent. If it destroys ten bacteria the index would be 1 per cent. The normal opsonic index of the human blood is $1\frac{1}{2}$ per cent. Opsonin is often added to the blood of patients when the opsonic index is below normal.

Pus-forming Bacteria.—Certain bacteria, when grown in the tissues, cause inflammation and form pus. These pus-forming bacteria cause boils, carbuncles, abscesses, erysipelas and blood poisoning. Tonsilitis and appendicitis are usually caused by these germs.

Anthrax.—Anthrax is an acute, infectious disease of domestic animals, particularly ruminants and horses.

History.—The disease was known by its present name in the oldest times (from the Greek word meaning coal) on account of the black color of the blood.

Anthrax has made its appearance the world over, outbreaks occurring alike on the Siberian steppes and the moisture-saturated

Louisiana lowlands. Anthrax has been epizoötic in Missouri at intervals since 1836.

It is more common in the early spring and summer, although cases are not infrequently observed in winter.

The cause of anthrax is the anthrax bacillus (Bacterium anthracis), a spore-forming, somewhat large, rod-shaped organism with square ends. The germ is not easily destroyed outside of the animal body, and pastures, stables, or material such as hides, etc., infected with the bacillus, may harbor it for long periods. Infection

Anthrax bacilli in chains with spores.

may follow, when taken into the body in the food, through inhaling air laden with infected dry dust, or through the broken or even healthy skin.

Once gaining access to the body, it meets conditions favoring its development and multiplication. It also grows outside of the animal body, and pastures once infected may carry the germ for many years. If it is placed under unfavorable conditions it forms spores, and these are so resistant to destructive agents that they may lie quiescent for long periods of time, only again to form virulent germs if they gain access to the body. Thus a grave where an animal killed by anthrax has been buried may keep a pasture

infected for nine or ten years, and a running stream contiguous to the grave may carry infection along its course. Fodder or hay cut from the neighborhood of the grave may also carry the infection. Cattle driven through an anthrax-infected district may contract the disease, and one sick or dead animal may infect a wide area.

Animals killed by anthrax, or suspected anthrax, should not be opened or skinned, as these operations are often followed by infection of the operator, and may result in the further spread of the disease among other animals. Infection may easily be carried also by flies, dogs, cats and other animals. Even wool-waste or leather-scrap may transport the disease if these materials are used as fertilizers.

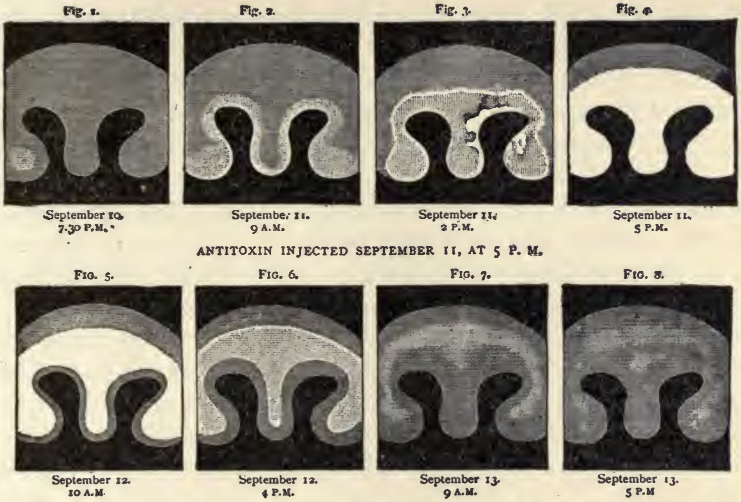
Whenever possible the carcasses of animals killed by anthrax should be cremated; and under no circumstances should the hides be sold, as, whether wet or dry, they are a source of great danger. As anthrax is most common in hot weather, persons handling the sick or dead animals should be careful to guard thoroughly against the danger of being bitten by flies or other insects that may carry the infection. A thorough disinfection of person and clothing must follow every exposure.

Men who handle hides from infected animals often have carbuncles on their hands and shoulders. Wool-sorter's disease is due to handling the wool of infected sheep. Carbuncles develop on animals which offer great resistance to anthrax.

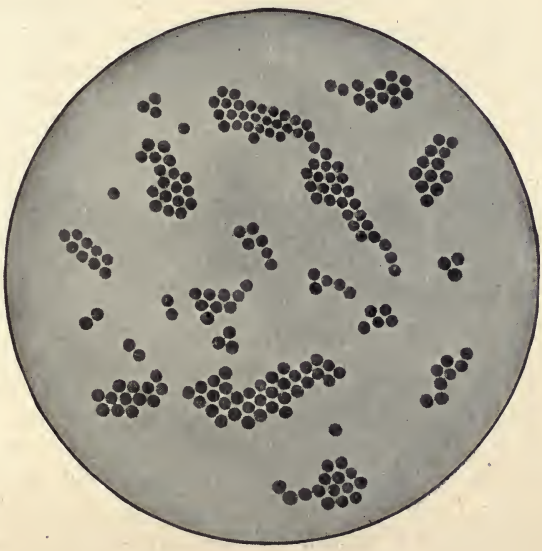
The incubation period of anthrax, or charbon, is from two to twelve days; consequently vaccinated animals which develop the disease within a period of twelve days after vaccination, had contracted the disease before they were vaccinated.

The most common source of infection is probably through the animal taking in the bacilli when grazing on infected pasture or drinking infected water, or through the bites of insects, flies, mosquitoes, etc.

Because of this disease, the greatest precautions must always be taken. Pastures or stables once infected are a grave menace for years. Streams running through polluted pastures may carry the disease and distribute it for miles.



DIPHTHERIA IN A CHILD AGED FIVE YEARS, SHOWING RAPID GROWTH OF MEMBRANE ON TONSILS, UVULA, AND SOFT PALATE, AND ITS SUBSEQUENT RAPID DISAPPEARANCE UNDER THE USE OF ANTITOXIN.



Other forms of bacteria.

Symptoms.—The symptoms of anthrax vary with the species of animal and with the virulence of the attack. In what is commonly termed "fulminating anthrax" it may well be said that there are no symptoms. The horse drops dead in the harness or the cow in pasture without the exhibition of any symptoms whatever. It is a common experience for the veterinarian in an anthrax-infected district to find that cases of supposed death by lightning are really deaths from acute anthrax.

Disposal of Animals.—Cremation is the best method for the disposal of animals which have died of anthrax. Dig a hole of sufficient size and place iron rails across it in such a way as to support the animal clear of the bottom. Make a good fire under it, and when the draft has gained enough headway, cover the animal with wood saturated with coal oil. Keep up the fire until nothing remains except the incinerated bones. A bad cremation is a serious menace to the community.

Disinfection.—The barn should be scrubbed with strong soda-solution containing Krelos or other disinfectant, especial care being given to the mangers, racks and floor; and then, if possible, close the barn tight and disinfect with formaldehyde. Lastly, whitewash, adding one pound of Krelos or some crude carbolic acid to each barrel of the wash. Lime should be used freely on floor, barn-yard or area where the infected animal has been. The manure from the barn-yard should be hauled out and burned. It is well to remove a few inches of the soil beneath the manure, replacing it with fresh gravel.

When an animal develops anthrax the stable or pasture must be regarded as an "anthrax-infected premise" and considered unsafe for unvaccinated animals. Animals properly vaccinated do well on infected premises, though susceptible animals may die of anthrax within a short time.

Prevention.—Louis Pasteur discovered the method of preventing anthrax. Anthrax bacilli, which are grown at a temperature between 108° F. and 109° F., lose the power to produce disease when injected into an animal, but do not lose the power of stimulating the animal to build up germicidal substances to combat the disease. Doses of anti-anthrax serum are injected into animals. Usually a small dose is given, followed in two weeks by another

dose. Doses of from 80 to 100 cu.cm. have been used on large animals and also on man at intervals. As a rule much smaller doses are used.

Three strains or "seed" cultures are used—Anthrax Vaccine Culture, No. 1, will kill white mice, but not guinea-pigs; Anthrax Vaccine Culture No. 2 will kill guinea-pigs, but not rabbits, and Anthrax Vaccine Culture Single will kill white mice and young guinea-pigs, but not full-grown guinea-pigs or rabbits. Anthrax Vaccine Culture No. 3 will kill guinea-pigs and some rabbits.

Cattle, horses, mules, sheep, goats, and swine should be vaccinated annually, in the spring of the year, at least two weeks prior to the usual appearance of the disease or to the time when the animals are turned out on infected premises.

Hookworm Disease.—Although this disease is not due to bacteria, it should be mentioned because it is caused by a parasite, and because of its evil effect upon human beings.

The worm enters the system from the ground through the skin of a bare foot, or by the eating of fruit which has been on ground infected by hookworms.

The worm attaches itself to the inside of the intestines and sucks the blood from its victim, sapping a human being's strength, lowering his vitality, and stunting the physical and intellectual growth. The hookworm disease is common in the southern states of our country, causing much misery and poverty, and making school children stupid and indifferent to progress.

As the worm does not multiply in the stomach, it cannot reach a person's system unless by the methods already mentioned. Thorough disinfection and wearing shoes prevent the worm from multiplying. A treatment of Epsom salts and thymol under the direction of a physician removes the worm from the body.

Fire Blight of the Pear and Apple Tree.—Fire blight is caused by a bacterium which grows in the juicy part of the stem between the wood and the bark. This tender fresh layer is called **cambium.** This is the part which breaks and allows a boy to slip the bark off when he is making a whistle.

The growth of new wood takes place in the cambium, which is full of nourishment. The bacteria live on this nourishment, de-

priving the limb of the food necessary for its growth, and causing the twig to have a blackened, withered appearance. Leaves often remain on such twigs during the winter time. The limb should be cut off with a knife which has been dipped in a 5 per cent solution of carbolic acid, and the places sealed with wax to prevent insects and birds from carrying the disease from one tree to another.

Black Knot.—Black knot is one of the most serious known diseases of trees. It is contagious. Large black knotty excrescences grow on the limbs of trees. These should be cut off and burned as soon as observed. The disease attacks plum and cherry trees especially.

Fruit Mold.—Cherry and peach trees are often seriously affected by a brown rot which attacks the unripe fruit on the tree and turns it soft and brown with a fuzzy coat of mildew. It is usually prevented by spraying the tree several times with a self-boiling lime sulphur wash.

Oat and Wheat Smut.—On very young oat and wheat plants a disease develops which causes the blackening of the heads of grain. If such grain is threshed, this black part, consisting of the spores of tiny fungus plants, is driven into the air. These spores will settle on the seeds and, if planted, will cause the disease to thrive in the next crop. If the seeds are soaked for a few minutes in a solution of formaline, the bacteria will be killed.

Potato Scab.—Scabby potatoes are caused by the growth of bacteria. Seed potatoes should be soaked in a ½ per cent solution of formaline for two hours.

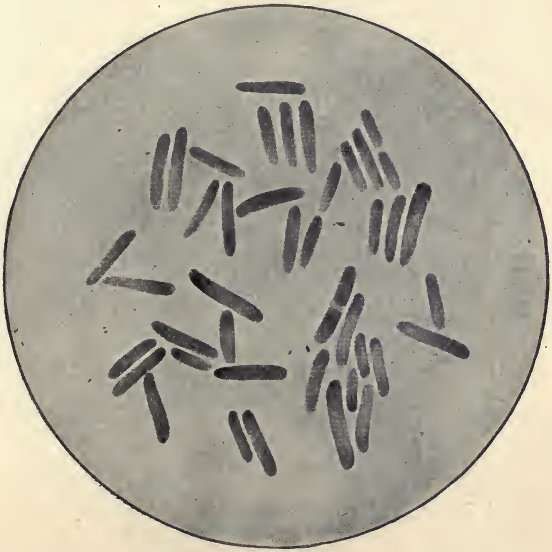
Potato Blight.—Another destructive disease of potatoes is caused by a fungus which attacks the foliage of potato plants. Potato fields must be sprayed in order to prevent the growth of this blight.

Club Root.—Club root is a disease of cauliflowers, turnips, cabbage, etc., which causes the appearance of large knotty bunches on the roots. Eighty or ninety bushels of lime per acre prevent the development of this disease.

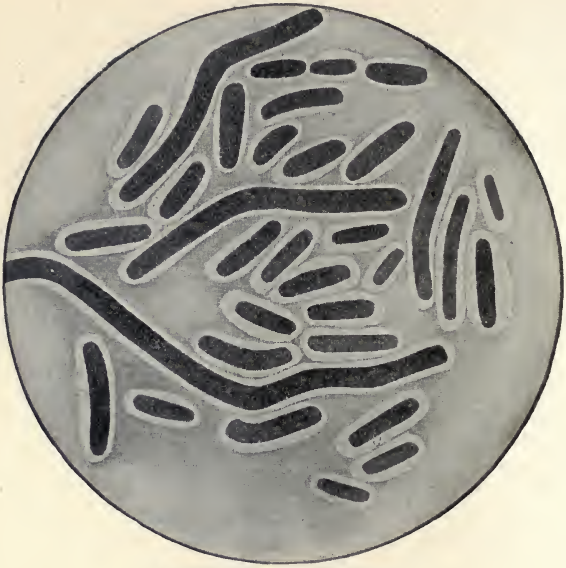
Questions

1. Why must an attack of measles be considered serious?
2. How may the germ be prevented from spreading?
3. Why is it possible for people to get scarlet fever from handling material in an attic?

Mixed infection.



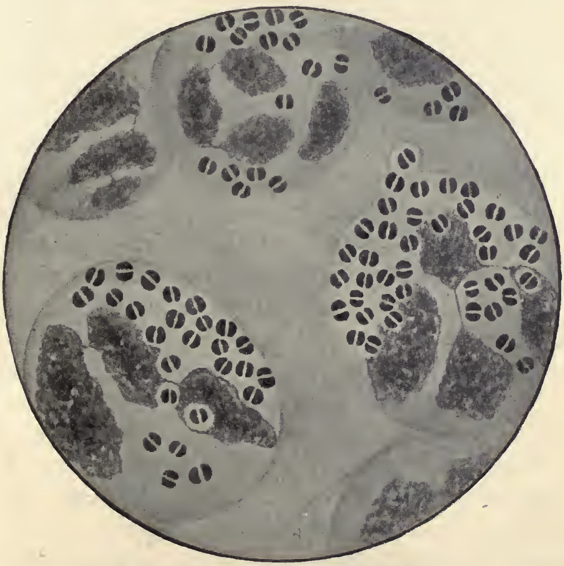
Bacillus coli communis.



Bacillus of Friedlaender.

Streptococcus. Bacteria forming in chains.

Pneumococcus diplococcus of pneumonia.



Gonococcus Neisser. A contagious inflammatory disease.

4. Why may scarlet fever always be considered a serious disease?

5. Why will tetanus (lock jaw) germs die if exposed to sunlight and air?

6. What are some of the sources of tetanus germs?

7. Why are people sometimes seriously ill from ptomaine poisoning after eating canned food?

8. Why should a wound under a finger nail be carefully attended to?

9. What are the chief sources of blood poisoning?

10. What is the value of determining the opsonic index of a person?

11. Why does pus form in some cases of inflammation?

12. Why is the hookworm a detriment to civilization?

13. What diseases of trees caused by bacteria should one be careful to look for?

14. How can you tell by the appearance of a potato whether it is diseased or not?

15. Find a potato infected with potato scab.

16. Why should children be kept home from school if a child in the family has measles?

BACTERIA USEFUL TO MAN

Useful Bacteria.—We have studied a great deal about harmful bacteria. There are many more bacteria which are useful to man and animals.

Bacteria in the Soil.—Plants require a large amount of nitrogen in simple compounds of nitrates and nitrites. Much of the fertilizer which is put into soil contains large quantities of nitrogen in compounds which are not available for the roots of the plants. Large numbers of bacteria in the soil attack this material, and change it into compounds which are useful food for the plants. Sometimes the soil has so few bacteria in it that farmers plant certain types of vegetables on which other bacteria live. On such plants as clover, cowpeas, vetches, alfalfa, the bacteria form knotty growths called **tubercles.** Through the activity of such bacteria, large quantities of nitrogen are taken from the air to enrich the soil. Encouraging the growth of such bacteria obviates the necessity of buying large quantities of expensive fertilizers.

Bacteria in Milk.—Among the most common bacteria in milk are those which produce **lactic acid** and cause the milk to sour. Lactic acid bacteria are useful in the stomach, as they oppose other bacteria which may be harmful or produce **putrefaction.**

To-day there are certain types of tablets sold on the market which are supposed to contain bacteria to be taken either in the form of

Fig. 193.—On the left, clover growing in soil uninoculated. On the right, clover growing in soil which has been inoculated.

a pill or dissolved in milk. The bacteria oppose harmful bacteria found in the body.

Bacteria in Butter and Cheese.—Cheese is usually ripened with the use of molds and bacteria. Some types of cheese, such as limburger, are placed in moist cellars from four to six weeks to allow the bacteria to grow. This process is closely related to putrefaction, causing the cheese to have a disagreeable odor.

Cream is ripened through the aid of bacteria. Sometimes germs or ferments are added to cause the cream to ripen quickly.

Fresh butter contains a large number of bacteria. When butter is a day old it contains about one-half as many bacteria as when first produced, and by the second day the number of bacteria has been reduced to $\frac{1}{25}$ of the original number. In butter a month old the number of bacteria present has been very greatly reduced.

Project.—Send for pamphlet on "Butter and Cheese Making," U. S. Department of Agriculture.

Bacteria in Vinegar.—We have learned that the bacteria in bread change the sugar to alcohol, and if bread is not well-baked they will change the alcohol into an acid. Bacteria which change alcohol into acids are used to produce the acid in vinegar. "Mother of vinegar" is a mass of bacteria.

Bacteria in Textiles and Fibers.—Bacteria are often used for rotting the stems of flax, hemp, and many other fibers, until the surrounding tissues are soft.

Bacteria, Useful for Decomposition.—Certain types of bacteria are used to-day to change dangerous sewage into harmless material. Even disease-producing bacteria are killed by such methods. Small private sewage systems allow the sewer to run through porous tile drains around which decomposing bacteria are working, converting the sewage into harmless substances which may be used by the roots of trees and other plants.

Life which exists upon the earth to-day depends to a great extent upon the decomposing action of bacteria.

Project 1.—Make a report on Conn's "Bacteria, Yeast and Mold in the Home."

Project 2. Lippman's "Bacteria in Relation to Country Life."

Questions

1. Why do we have an impression that most bacteria are harmful?
2. In what ways are bacteria useful?
3. Why is it necessary to have bacteria in vinegar?
4. How do bacteria assist in the manufacture of linen?
5. Why would it be almost impossible for man to live without the aid of bacteria?

METHODS OF PREVENTING AND SPREADING DISEASE

Quarantine.—The only way to safeguard the public from contagious diseases is by quarantine. People who do not conscientiously keep all quarantine regulations and restrictions are poor citizens.

Quarantine is the adoption of measures to prevent the introduction of diseases from one locality to another.

Patients suffering from contagious diseases are often sent to "Isolation Hospitals." If the patient must be kept at home, or is allowed to remain at home, the house is quarantined for a certain length of time, depending upon the disease. A placard is placed on the house, and the occupants of the house are restricted in their movements. Regulations are different for different diseases.

Fumigation.—After the recovery of the patient, the room or house must be disinfected to kill all germs. This is usually done by **fumigating** through the use of sulphur fumes or formaldehyde. Fumigation, to be effective, must be done by an experienced person. The Board of Health frequently attends to it.

How to Prevent the Transmission of Disease Germs.—The hands are great germ carriers because they come in contact with all kinds of germ-laden articles, as books, pencils, door knobs, street car straps, and other hands. Millions of germs can collect under the finger nails. Keep the hands clean, using plenty of good soap. Form the habit of keeping the hands away from the mouth, nose and eyes. Never eat food with soiled hands.

The banishment of the common towel and drinking cup has helped to stop the transmission of disease germs.

Dust is a great carrier of germs. Streets should be sprinkled and cleaned. Some damp material should be used in sweeping the floors of public buildings. Houses should be swept with damp brooms, carpet sweepers, or vacuum cleaners to keep down dust. Dusting should be done with a damp or oiled cloth that will remove the dust and not scatter it.

Never buy candy or fruit left uncovered to collect dust and germs. All food left exposed to the dust of the air should be properly cleaned before eating. Roadside berries or fruits may have harmful germs in the dust which has gathered on them.

Care of Wounds.—All wounds should be washed with a disinfectant before being "tied up." After bandaging a wound, watch it carefully, for at the first sign of inflammation it must be opened and disinfected. The slightest pricks, scratches, cuts and burns, if not properly attended to, may develop cases of **blood poisoning.** The following disinfectants may be used for treating infected wounds and sores:

Hydrogen Peroxide, Boric acid, Iodine, a weak solution of Carbolic acid, Carbolic salve, Lysol, Bichloride of Mercury, Turpentine, and warm salt solution.

Great care should be taken when hydrogen peroxide is used as a disinfectant. The oxygen set free from the solution destroys not only the bacteria but the cells in the wounded flesh. The wound should not be closed up with hydrogen peroxide or dioxide in it because decay of the flesh may take place, causing a great deal of trouble.

Disinfectants.—A disinfectant is an agent which destroys disease germs.

It is necessary to use disinfectants around water-closets and sinks. Chloride of lime is a cheap and powerful disinfectant for this purpose.

Infected articles of little value, and cloths and papers containing sputum, may be disposed of by **burning.** **Boiling or sterilizing** is an effective way to kill germs.

Most of our chemical disinfectants are so poisonous that great care must be exercised not to use them internally by mistake.

Disinfectants must be used in all cases of contagious diseases. Discharges from the patient must be received in a strong disinfectant, and everything that comes in contact with the patient must be disinfected or sterilized.

Bichloride of mercury is an excellent disinfectant for the hands, and for washing woodwork and furniture. It must not be used on metal. It is not used in cases of intestinal disease.

Carbolic acid in five per cent solution is good for almost any purpose.

There are many commercial disinfectants, as Lysol, Creoline, etc., which may be used under direction of the doctor.

Burning of substances in a sick room to kill unpleasant odors does not necessarily kill germs.

Direct Sunlight as a Germicide. Direct sunlight kills the bacteria that are the cause of most human diseases. Such bacteria do not require air to live, and are known as **anaërobic.** If it were not for the ability of sunlight to kill dangerous bacteria which are about us everywhere in the open air, the human race might soon become extinct. The winds would carry the diseases from place to place, and no home would be safe from sickness. In the sunlight there are ultra-violet rays, rays of light which do not affect the human eye. Whenever bacteria fall under the influence of these rays in strong sunlight they are killed. Ozone formed by the ultra-violet rays probably also assists in killing bacteria. We know how strong this substance is as it often causes colors to fade in rugs or draperies left in direct sunlight. Physicians are using ultra-violet rays for special treatment in cases of certain diseases. In fact, direct sunlight is the most powerful germicide known.

Questions

1. Why should people not object to quarantine?
2. Why should all people who are quarantined be glad to obey the rules of the Board of Health?
3. What is the best way to prevent the transmission of disease?
4. How do you care for wounds at home?
5. When should disinfectants be used?
6. What is the best disinfectant?
7. Why should all rooms be well lighted?
8. What care should be taken of badly soiled handkerchiefs?
9. Why should one wear gloves when traveling?
10. Why should reservoirs be open at the top?
11. Why is it well to have a school room so situated that the sun shines directly into the room during a part of the day?

CHAPTER X

LIGHT AND ITS RELATION TO THE WORLD

LIGHT WAVES

Sources of Light.—The great source of light is the sun. Fig. 105, page 138. However, we have many minor sources, such as gas, oils, and electricity. Bodies which give off light of their own accord are said to be **luminous,** and bodies which give off reflected light are said to be **illuminated.** The light which comes to us from the moon and that from the paper on the wall are examples of reflected light. Bodies which do not give off any light are said to be **non-luminous.**

How Light Travels.—Scientists believe that light travels in the form of waves, not like the waves of the ocean, but waves which travel in direct lines in all directions from the source of light. It also takes time for this light to travel. It has been discovered that light travels at the rate of 186,337 miles per second; in other words, it takes about eight minutes for the light to come to us from the sun. The length of time required for light to travel to us from the North Star is about forty-six years. (How far away is the North Star?) This means that if the North Star should be destroyed to-night we would continue to receive light from it for a great many years to come. There are some stars so far away from us that it requires two hundred years for their light to reach us.

The vibrations which cause light are called ether vibrations. Ether is the invisible substance which fills all space. When the vibrations are

Trillions per second it produces the X-ray.
2000 billions per second it produces the photographic ray.
750 to 400 billions per second it produces light.
230 billions per second it produces Hertzman waves for wireless.

The waves in wireless vary from a few feet in length to over a mile.

The diagram shows the ether waves used for wireless, then a space of vibration about which we know nothing, as we have no instrument delicate enough to measure them. In the next space are waves of heat which we feel but do not see. Next is a space where the waves affect the optic nerve, and we see. These are called light waves. As the number of vibrations increases, there are created ether waves which in photography produce chemical changes and also

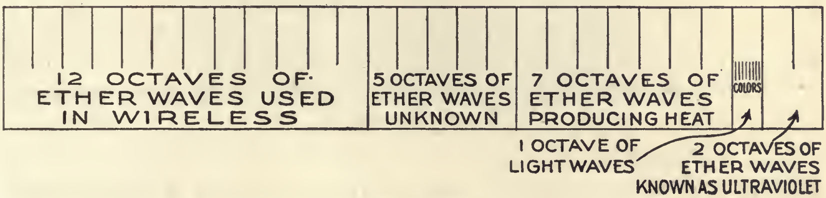


Fig. 194.

kill bacteria. These vibrations cause the ultra-violet rays. Beyond this space the vibrations of ether are entirely unknown.

Transparent, Translucent and Opaque Objects.—When light passes through a substance without being diffused we are able to see objects through the substance, which is said to be **transparent.**

When light passes through a substance, like paper or ground glass, and we are unable to see objects through it, the substance is said to be **translucent.**

A substance which will not permit transmission of light through it is said to be **opaque.**

Shadows.—When rays of light are cut off by an interposed body, a shadow is formed usually representing in silhouette the form of the interposed body.

Our night is caused by the shadow of the earth. The sun is shining on one side and the rays of light are unable to illuminate the other side of the earth. The eclipse of the moon is caused by the shadow of the earth touching the moon's surface. Sometimes the moon comes between the sun and the earth. The moon's shadow

then touches the earth and causes a dark area which we call the eclipse of the sun.

Shadows are divided into two parts; a dark center called the

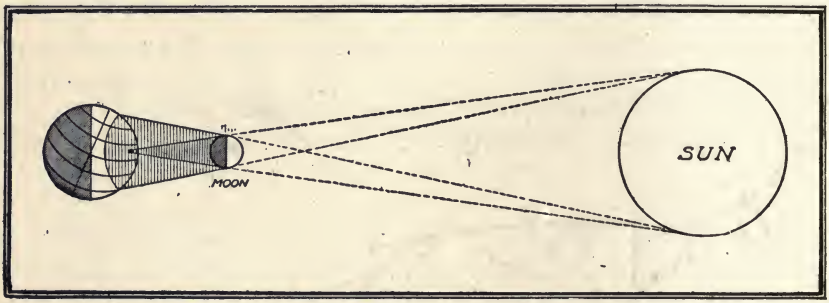


Fig. 195.—Eclipse of the sun.

umbra, and a border on all sides of the umbra of a much lighter fringe called the **penumbra.**

Questions

1. Why do you cast a shadow?
2. Why are shadows longer in the afternoon than at noon?
3. Why are shadows so short at noon?
4. Where on the earth would a shadow always be of the same length?
5. What causes an eclipse? What is a partial eclipse?
6. Why are clouds sometimes black?
7. Why do stars twinkle? Why do planets glow with a steady light?
8. How do scientists know that there are vibrations which do not cause any sensation upon the nerve centers of human beings?
9. How are silhouettes made?
10. Why is a shadow behind us when we are facing the light and in front of us when the light is at our backs?
11. Can a piece of glass be made to cast a shadow? Explain.
12. Will a shadow increase or decrease in size when one holds an object nearer to the light?

REFLECTION

Kind of Images.—There are two kinds of images, real and virtual images. The real image is the image which is actually produced by a lens or mirror, and can be found on a screen. The images caused by cameras, lenses, by the eye, by moving picture apparatus

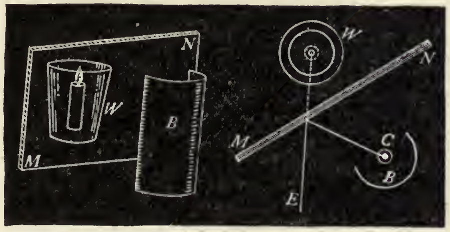


Fig. 196.—How Pepper's Ghost is produced.
Tower, Smith and Turton Physics.

and projection lanterns are real images. A virtual image is an image which cannot be found on a screen. Such images are produced by plain mirrors. When a person looks into a mirror an

Fig. 197.—How the moon sends us its light.

image is seen, apparently behind the mirror. There really is no image behind the mirror.

The optical illusion called Pepper's Ghost is produced by the use of a virtual image. The room is darkened.

FIG. 198.—Here we see the officers of a submarine studying the picture of what is happening above, which the periscope has reflected upon the table somewhat in the same way as a picture is thrown upon the sheet by a reflectoscope. *Courtesy Child's Book of Knowledge.*

FIG. 199.—These men are taking a last look round before sinking. Air-compressors maintain the supply of air in a submarine. Formerly, white mice used to be kept on board to indicate, when they fainted, that the air was getting foul. *Courtesy Child's Book of Knowledge.*

A glass of water W is placed behind a piece of plate glass MN and a lighted candle in front of the glass, behind a shield B, the open side of the shield facing the glass. The observer stands behind the shield B. The image of the candle appears in the glass of water. Virtual images of this type are used to produce stage ghosts, etc.

Why images are seen in plain mirrors. — Any smooth surface, such as glass, water, polished wood or polished materials, produces images because the rays of light striking the smooth surface are reflected back. If the surface is irregular the rays of light are reflected at all angles and diffused.

Light shining on the objects about us, such as plants, houses and animals, is reflected into the eyes and enables us to see the various objects about us. The moon is seen because sunlight is reflected from its surface to the earth.

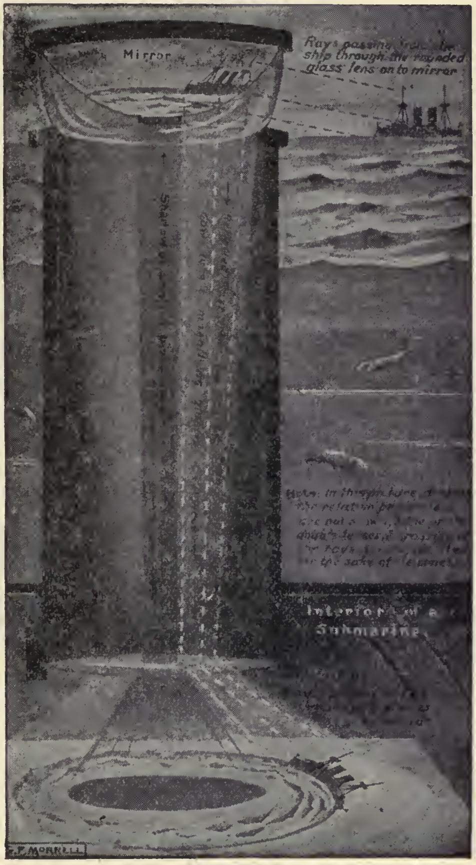


FIG. 200.—In this picture we see how the periscope works. The ship on the waves is seen by the lens of the periscope, and the picture is reflected down the tube on the table.

Courtesy Child's Book of Knowledge.

Different phases of the moon depend upon the amount of surface toward us which is reflecting light. The new moon is reflecting light with one-half of its surface toward us.

The use of a mirror to reflect light so as to produce images is very important in the submarine. The periscope is made up of a round barrel containing mirrors which reflect the light down into the interior of the submarine, thus giving a picture of the surroundings when the top of the periscope is above the water.

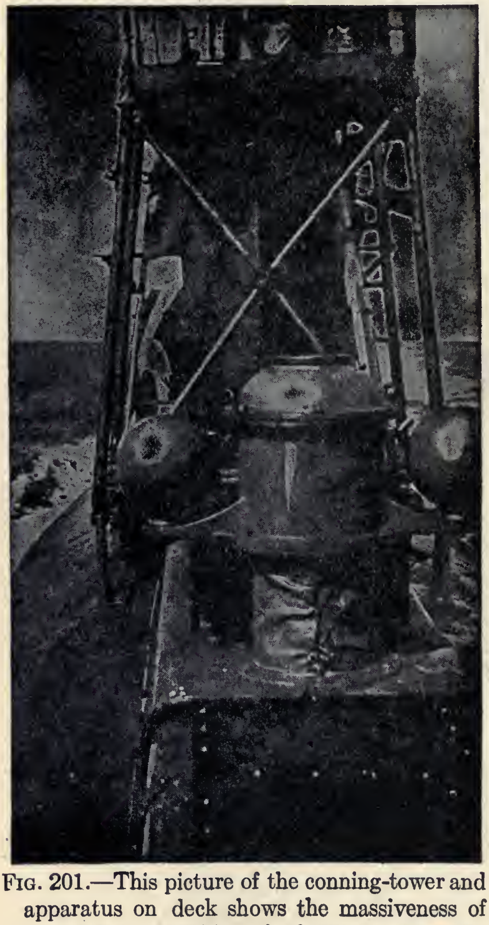


Fig. 201.—This picture of the conning-tower and apparatus on deck shows the massiveness of the most modern kind of submarine. New and larger types are constantly being built.
Courtesy Child's Book of Knowledge.

Mirrors are also used for signal work in an instrument called the heliograph.

With a mirror try to reflect rays of sunlight to different parts of the room.

Law of Reflection.—A person standing directly in front of a mirror sees his own image, but if he stands at the side of the mirror he is unable to see his own image, although it can be seen plainly by a second person standing on the opposite side of the mirror. The reason for this is easily seen when we know that light is reflected at the same angle at which it hits the mirror. This is called the law of reflection, and the angle formed by the ray coming to the mirror is called the angle of incidence. The angle formed by the ray which is reflected from the mirror is called the angle

of reflection. The angle of reflection always equals the angle of incidence.

Kinds of Mirrors.—Mirrors are divided into two classes, plain and curved. The curved mirrors are redivided into two types, the **concave** and the **convex.** The mirrors may be spherical concave or cylindrical concave or convex. The concave spherical mirror is used for reflecting light upon the teeth, into the throat, and into the ear. It is also used in headlights and for reflectors of lights. The inside and outside of a silver spoon furnish good examples of mirrors of this type. Find other examples about your home.

Fig. 202.

The convex spherical mirror is used on automobiles so that the driver may see the road behind without turning his head.

Parabolic Mirrors.—Mirrors are sometimes constructed so as to produce a parabolic surface. This causes the rays of light which are reflected from the mirror to travel in parallel rays. This reflector is used in automobile lamps, searchlights, headlights of locomotives, bicycle lanterns and carriage lamps. The light is placed at the principal focus of the mirror.

Questions

1. What kind of an image do you see in polished sheet iron?
2. Why do you see an image when you look at the metal?

3. Why do you not see an image when you look at paper?

4. Why is well-glazed paper bad for the eyes?

5. Why is it possible to see an image in a window?

6. Why is it difficult to look into a room from the outside through a window when the sun is shining brightly?

7. Why do you shield the face with the hand when you wish to look into a room from the outside through a window when the sun is shining brightly?

8. How does the submarine captain see objects on the surface of the water by the aid of the periscope?

9. Why is it necessary to have parabolic mirrors in search lights?

10. What have you about your home in which curved mirrors are used? Explain why.

REFRACTION

Refraction of Light.—If a pencil is placed in a dish of water and looked at from one side it will appear to be broken or bent. This

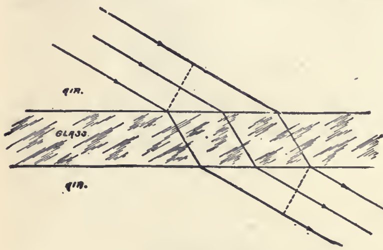


FIG. 203.

FIG. 204.—How the light rays are bent in passing through a prism.

is due to the light rays entering the water, which is a denser medium than the air. When light rays enter a denser medium they are bent downward, causing objects to appear larger, or bent, or broken.

A coin placed at the bottom of a dish full of water seems to be higher up, and if a person looks directly over the edge of the dish, it is possible to see two images of the coin at the same time. The image of the sun is seen before the sun rises, because of the rays of light which are refracted by the light entering the air, a denser medium than that in which it was traveling before it came in con-

tact with the atmosphere of the earth. This image is usually large and red. The same thing happens at sunset.

Refraction in a Prism.—Light rays entering glass are bent, since the glass is a medium denser than air. Light rays entering glass made in the form of a prism are bent according to the position the prism is in when the light rays pass through.

In Fig. 205 it will be seen that the light rays entering the prism are bent so as to be reflected back on the other side of the prism. Use of this is made in instruments called binoculars.

The rays of light are made to pass three times the length of a barrel in going from the objective glass to the eyepiece of each barrel. Thus, by means of a short tube, the equivalent of a telescope is obtained.

The prism is used in some headlights of automobiles for bending the rays of light so that they will fall on the road below the vision of the driver of an approaching automobile.

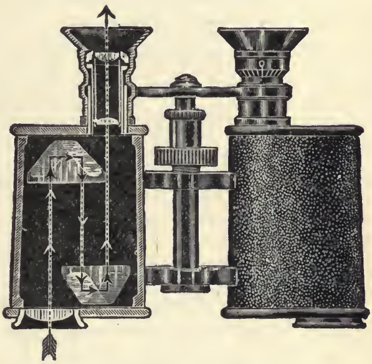


Fig. 205.—Notice how the prism bends the rays of light, causing the light to travel a great distance.

Why a Prism Breaks up Sunlight into Colors.—Light travels at the rate of 186,337 miles per second. This light is composed of many colors, as will be seen by placing a prism in the sunlight and looking for the band of color which it produces.

When light passes at an angle into a denser substance, the ray of light is made to travel more slowly, a fact which causes it to bend.

As will be seen from the following table, the long red waves vibrate less rapidly, and consequently are made to bend, or are **refracted** the least, and the shorter waves, which vibrate very rapidly, are refracted the most.

Scientists know that there are waves of light which we cannot see, as there are no nerves in the eye to be affected by them. The

color waves which vibrate more slowly than the red are called **infra-red,** and those which vibrate faster than the violet are called **ultra-violet** rays.

Place a prism in the sunlight and adjust it until a band of color is obtained.

All colors are traveling at the same velocity, but each color has a different number of vibrations per second.

Light.	Wave Length, Cm.	Wave Length, In.	No Vibrations per Sec.*
Red....................	0.000068	0.00002677	441 Billion.
Orange................	0.000065	0.00002559	461 "
Yellow.................	0.000058	0.00002286	516 "
Green..................	0.000052	0.00002050	576 "
Blue....................	0.000046	0.00001811	651 "
Violet..................	0.000040	0.00001574	740 "

* Approximately.

The Rainbow.—Rainbows appear early in the morning or late in the afternoon after a rainstorm has passed over the place. The sun falls upon the raindrops which act much in the same way as the prism, refracting the light and breaking the light waves up into the seven colors. No two persons see the same rainbow, as the same drops of rain are not reflecting the same rays of light into the different observers' eyes. The diamond shows much of the same reflection and dispersion of light as the little raindrops in the atmosphere. Diamond cutters cut the diamonds so as to get the greatest possible amount of light reflection.

Color of the Sky.—Outside the atmosphere the sun would be very blue and the sky black, but the rays of light from the sun, after passing through the atmosphere, have nearly all the blue color sifted out by the atmospheric moisture and dust particles which reflect the blue, giving the appearance of a blue sky. The other colors pass around the particles of the atmosphere more readily. As the amount of dust and moisture increases, different rays of light are reflected, producing beautiful sunsets, and often making it possible to predict the kind of weather for the following day.

During some volcanic eruptions a great amount of dust is thrown into the air. The more dust in the air, the greater the loss of the blue, and the greater the predominance of red and yellow.

Sunset Colors.—When the rays of light from the sun strike the earth in a slanting position, the clouds act as prisms, separating the light waves and allowing those colors to pass through which are least turned from their course. Yellows, oranges and reds pass through. The amount and variety of color depend, however, on the thickness and height of the clouds.

A Mirage.—A mirage is an optical illusion which causes distant objects below the horizon to be plainly seen. This happens in hot, desert regions when the lower air near the ground is very much hotter than the air above. The lower air, being expanded, is not as dense as the cold air, which causes a ray of light traveling obliquely downward to be refracted until the angle of refraction is more than 90°. Then total reflection takes place. Images seen are inverted. On the Great Lakes, trees, boats and towns on the opposite shore sixty or seventy miles away are sometimes plainly seen. The images are usually erect, and are caused by the total reflection from the warm still layers of air over the cold layers near the water.

USE OF LENSES

Lenses.—Lenses may be considered a series of prisms, one placed upon the other, and each one slightly different from the others.

Focus of a Lens.—When the rays of light enter a lens they are bent so as to meet at a point called the focus. The thicker the lens the nearer the focus is to the lens, and the thinner the lens, the further away the focus is from the lens.

Effect of Object Distance on Images.—The two principal features of a convex lens are the principal focus and the axis. The image produced by any lens depends upon where the object is placed in respect to the principal focus. If the object is at a great distance from the lens, the image is near the lens, and is small and inverted.

This is the case with the eye, the view camera, and the object glass of a telescope. If the object is twice the focal distance from

the lens, the image is inverted, the same size as the object, and at the same distance from the lens.

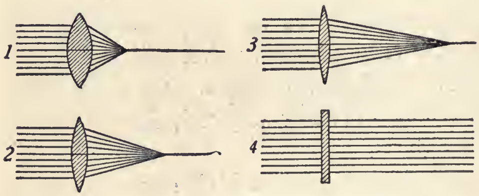


FIG. 206.—What causes the rays of light to meet near the lens and far from the lens?

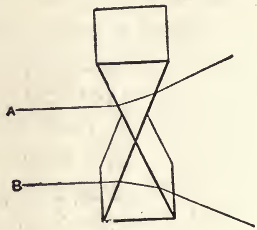


FIG. 207.

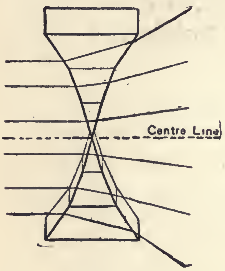


FIG. 208.

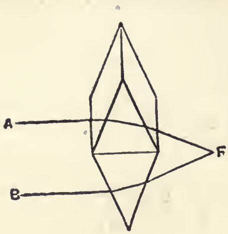


FIG. 209.

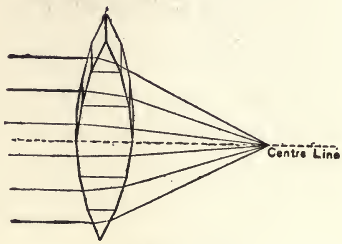


FIG. 210.

Development of convex and concave lenses.

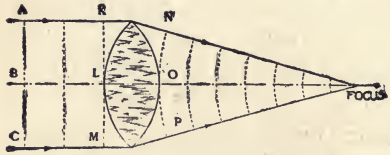


FIG. 211.

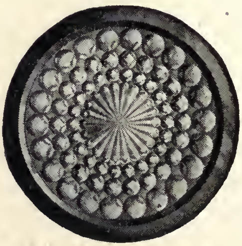


FIG. 212.—Lens to spread the rays of light for the head light of an automobile.

This plan is often used to make a copy of a drawing when the copy is to be exactly the same size.

If the object is placed near the lens the image is large.

This arrangement is used in enlarging cameras, moving picture apparatus and stereopticons, reflectoscopes, and the object glass of the compound microscope.

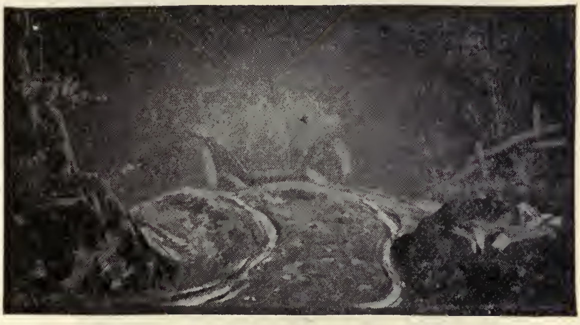


FIG. 213.—The rays of light spread over a road by a lens.

If an object is placed at the principal focus of a lens, no image is obtained. If the object is a light the rays of light pass out of the lens in parallel beams.

FIG. 214.

This principle is applied in the bull's-eye lantern, the lenses for automobile lamps, lighthouses, and spotlights on the stage.

If the object is placed nearer to the lens than the principal

focus no image will be formed. The rays of light will spread farther and farther apart.

FIG. 215.—The lens of a lighthouse. Notice how each part of the lens is so constructed as to cause the rays of light to pass out in parallel beams.

Condensers in Stereopticons.—Lenses called condensers are used in stereopticons to produce parallel rays. A transparent pic-

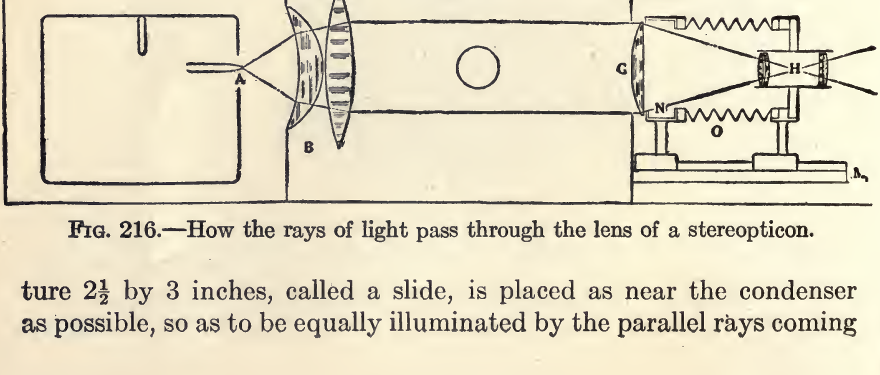


FIG. 216.—How the rays of light pass through the lens of a stereopticon.

ture $2\frac{1}{2}$ by 3 inches, called a slide, is placed as near the condenser as possible, so as to be equally illuminated by the parallel rays coming

from the condensers. The first condenser nearest the light makes the rays parallel and the condenser nearest to the lens brings the rays of light to a point, so that they will meet inside the lens called the objective.

It is possible to tell by the screen whether the light behind the objectives is adjusted properly. Numbers one and two show that the light is not in the center, but too much to the right and left. Numbers three and four show the results of the light being placed too high or too low. Number five indicates that the light is too near the condenser, and number six shows that the light is perfectly adjusted, at the right distance and in the center of the condensers.

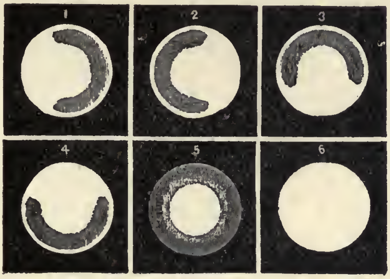


Fig. 217.

Motion-picture Machines.—A motion-picture film is a thin ribbon of transparent pyroxylin plastic, or nitrocellulose, which is highly inflammable: hence, the necessity of having the moving picture machine in a fireproof booth. The photographs (1 by $\frac{3}{4}$ inches) on the film are arranged one after the other, and are slightly different. There are sixteen of these pictures per foot. As a foot of film is supposed to be run through a machine each second, the audience sees sixteen different pictures per second. It requires at least sixteen different pictures to make a complete change of position—to move the hand from one position to another, to lift the arm, or to nod the head.

The audience does not see the pictures moving. In fact, each picture is made to stand still for a fraction of a second while the

audience sees it; that is, a person in the audience sees each second sixteen different pictures standing perfectly still. If the pictures do not stand perfectly still the picture looks streaked. In order to accomplish this a revolving shutter (731), Fig. 220, is used. The blade

Fig. 218.

moves over the picture as the picture moves. The blade and the pictures must move together to prevent a streaky look. If the shutter does not cover the picture at the time the picture is moving, streaks from the letters and flashes of white up and down are seen. This phenomenon is called " traveling ghost."

If the picture changes before the shutter covers it, streaks appear going down. If the shutter uncovers the picture before it is completely changed and comes to a stop, streaks and flashes of white are seen going up. Each picture must come to a complete stop before the shutter uncovers it.

With direct current a three-blade shutter is used. While the picture is standing still, the two other blades pass over it. With alternating current a two-blade shutter is used, one blade for the picture to move behind when changing, and the other to pass over the face of the picture while it is standing still.

The reason for having one or two blades pass over the face of the picture is to prevent flickering.

On each side of the film is a margin $\frac{5}{32}$ of an inch wide in which are perforations for sprocket wheels which feed the pictures to the machine.

Moving pictures were first made on very short films not over 75 feet long. They were mostly used for comic pictures. To-day films are several hundred feet in length and are used for many educational purposes.

The Taking of Motion Pictures.—Pictures of moving objects are taken by a camera which takes about sixty pictures per

Fig. 219.

Fig. 219.—A part of a film for a moving picture. Each picture is slightly different and if seen in rapid succession the automobile appears to be moving around the street corner.

second. As a rule, the operator takes only about 55 to 58 pictures. It will be readily seen that the pictures are not projected as rapidly. This causes strange illusions in certain types of pictures. The wheels of an automobile appear to be going around in the wrong direction. If the pictures were projected as rapidly

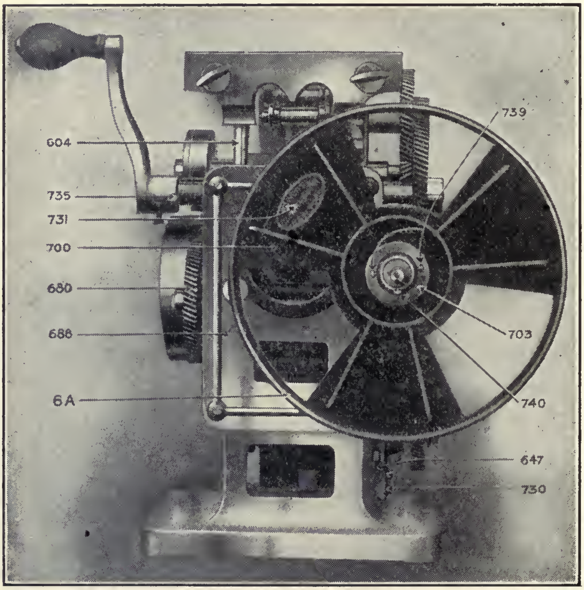


Fig. 220.

as they were taken, the wheels would appear to go in the correct direction.

Sometimes comic pictures are taken in which the people travel very rapidly. In such cases the moving picture camera has taken the picture very much slower than it is ordinarily taken. When the moving picture machine shows the picture, objects move very rapidly. If opposite results are desired, the pictures are taken very rapidly.

Questions

1. Why does a "bull's-eye light" look very large?
2. Why do fish look large in a globe-shaped aquarium?
3. Why does fruit preserved in cylindrical glass jars look large?
4. Why is it possible to see the sun before it is up?
5. Why does the moon look much larger on the horizon than it does higher up?
6. When looking at fish in water, is the fish which you see larger or smaller than the real fish, nearer to or farther from the surface?
7. Why do objects look broken or irregular through a window-pane?
8. Does a stick in water look larger or smaller, straight or broken? Why?
9. Why are prismatic colors sometimes seen at the edge of window-panes?
10. Why does an "Indigo red sky" signify rain?
11. Why are condensers used in a stereopticon?
12. When do you know that the light in a stereopticon is placed at the right distance from the condensers?
13. Why should people be careful about leaving broken bottles in woody places, where there are dry leaves, sticks, etc.?
14. Is the image on the ground glass of a camera real or virtual?

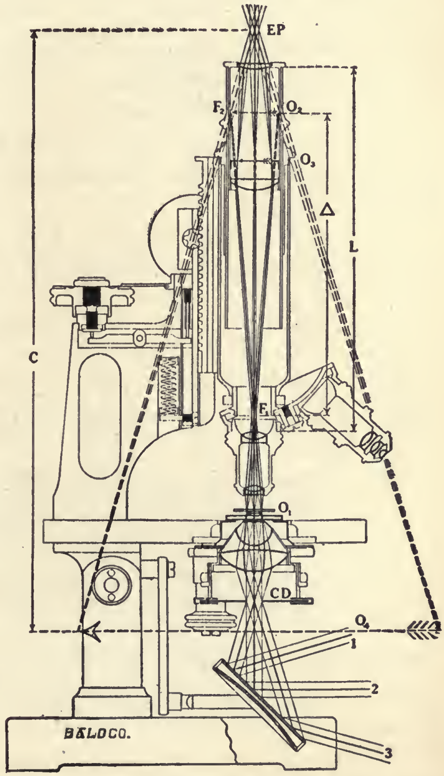


Fig. 221.—A compound microscope. O_1 is the object. O_4 shows how much larger the object looks. What do you think causes the object to form such a large image?

15. Why does an image look different in a silver pitcher from what it does in a mirror?

THE EYE

Results of eye trouble.—Many people suffering from indigestion, neuralgia, headaches, or mental exhaustion often find that such troubles are due to the eyes. Children who are wayward, incorrigible, backward, stupid, or defective, may be the victims of eyes which see things out of focus. The real remedy may be found in properly adjusted glasses.

The constant physical effort of trying to see things clearly with defective eyes uses up a tremendous amount of physical energy and vital nerve force.

Lens of the Eye.—The eye contains a lens which bends the light rays and brings them together at a point on the retina. We have

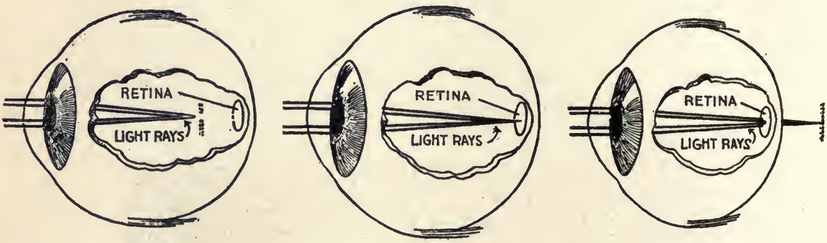
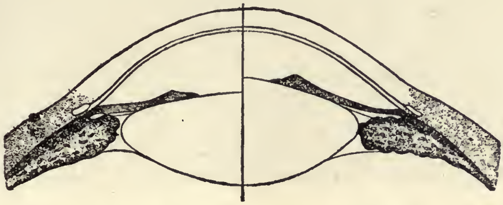


FIG. 222.—Myopia, short sightedness. Emmetropia, normal sight. Hypermetropia, far sightedness.

learned that a thick convex lens causes the light rays to meet at a point nearer the lens than does a thin convex lens. Sometimes the eyeball is too flat or too elongated to bring the rays of light to a point on the retina. If this is the case, the muscles of the eye must cause the crystalline lens, which is like firm gelatin, to become thicker than usual, and assume a more convex surface. Sometimes the eyeball is elongated, and the rays of the light do not meet on the retina but at a point in front of it. If this is the case the crystalline lens becomes more flattened.

The crystalline lens is held in position by an elastic capsule attached to the sides of the eyeball. Joining the surface of the eye-

ball back of the iris is a ring of muscular tissue. When this contracts, it constricts the iris and relaxes the capsule enclosing the crystalline lens. The lens becomes thicker. The eye is then able to focus upon nearby objects. If the eye wishes to focus on distant objects, the



This side is in a state of relaxation and is for viewing objects at a distance. Why is the lens thin?

This side is accommodated for near objects. Why is the lens thick?

FIG. 223.—Diagram of an eye in the process of accommodation.

opposite happens; the muscles relax, the iris expands and the lens becomes flattened. In old people the crystalline lens becomes hardened and does not adjust itself for different distances, thus making it necessary for many elderly people to wear two kinds of

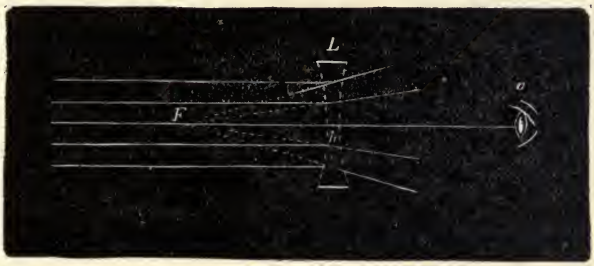


FIG. 224.—A concave lens spreads the light rays.

glasses; one pair for near work and the other for seeing distant objects.

If a person reads for a long time the muscles of the eye grow tired because of holding the lens in a certain position. We often notice the results of tiring the muscles when we suddenly raise the eyes from a book to some distant object. It seems to take a

moment's time for the eye to adjust itself so as to form a sharp image on the retina.

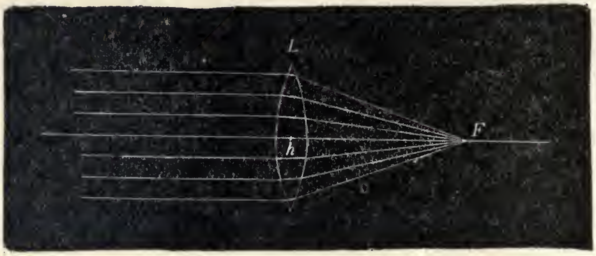
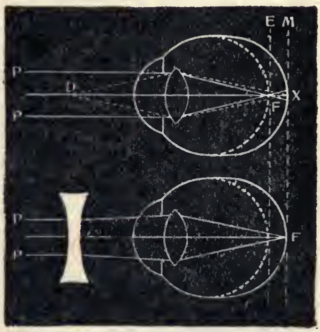


Fig. 225.—A convex lens brings the light rays together.

Near and Far Sightedness.—If the eyeball is flattened the person is said to be **far sighted** or to be suffering from **hypermetropia.** If the eyeball is elongated the person is **near sighted** or suffering from **myopia.** Artificial lenses must be placed in front of the eye in order to relieve the muscles from severe tension, and to bring the rays of light to a proper focus without undue effort on the part of the muscles.



Figs. 226 and 227.—The focusing of parallel and divergent rays in near sightedness. The correction of myopia by means of a concave lens.

Snellen Test.—Hold the test sheet twenty feet away from the person. Be sure the light illuminates it but does not shine in the eyes. Place the sheet on a level with the eyes. Test each eye separately by holding a piece of black paper over one eye. If the person wears glasses, make the test with the glasses on. If a person can read the lines marked fifteen feet, at a distance of twenty feet from the chart, that person is far sighted. If a person cannot read the line marked twenty feet, he is near sighted, and the seriousness of the trouble may be determined by the marking of the line which the person is able to read. Unless there is a sign of eye strain,

40 ft.

Z B D

30 ft.

F L C T

20 ft.

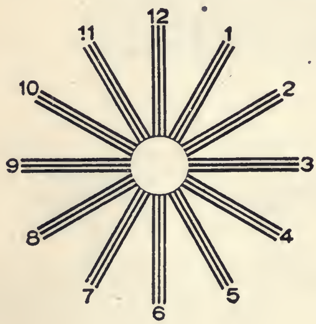
P E O R F D

15 ft.

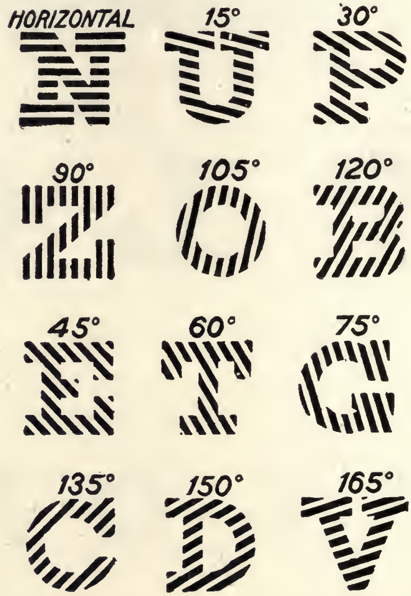
R T V Z B D F H

the person who can read only the line marked forty feet is seriously defective, and if the line marked forty feet cannot be read, the trouble may be considered serious. Headaches, swollen, crusted, or reddened eyelids, styes, inflamed eyeballs, squinting, blinking, twitching of eyelids, and wrinkling of the forehead indicate possible eye strain.

If a person is found to be near sighted, or suffering from astigmatism, consult the eye specialist immediately.



The above chart is used to test extreme cases of astigmatism. It is not always an absolutely reliable test, however.
Observe each letter and each radiating line. If any of the letters or lines look darker than others, astigmatism is present.



Astigmatism.—This defect of the eye is caused by the lens or cornea being unsymmetrical; that is, parts of the lens or cornea are so flattened as to cause some rays of light to be slightly out of focus while the eye is engaged in trying to produce a perfect image. This effort to supply power to the nerves and muscles causes twitching of the facial muscles of the eyelids.

Test for Astigmatism.—To test the eyes for astigmatism hold the diagram containing the radiating lines from two to three feet

away. Astigmatism is present if some of the lines are brighter and more distinct than others. The specialist will be able to tell whether

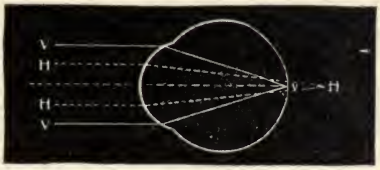


FIG. 228.—Astigmatism. A part of the lens or cornea of the eye is defective, causing the rays of light, H, H, to meet beyond the retina. Why do the rays of light, V, V, meet on the retina?

the person is suffering from compound or a simple form of astigmatism.

Evidence of Eye Strain.—Headaches which occur regularly, becoming worse as the day advances, are a strong evidence of defective eyes. Often a feeling of nausea and a sense of fatigue after a strenuous day's " close " work are due to eye strain.

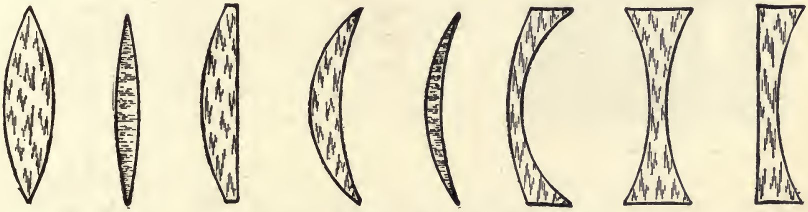


FIG. 229.—Different kinds of lenses.

The cause of the agonizing headaches, dyspepsia, loss of appetite, and insomnia from which so many school boys and girls suffer may often be traced to diseases of the eyes.

The strain and fatigue of the eye muscles is communicated to the centers governing the **pneumogastric nerve,** which has a great influence over the stomach and digestion.

Cause of Seasickness.—Sometimes people are made sick by the constant changing of the focus of vision caused by looking at the horizon over the side of a vessel that is rising and sinking with the

motion of the waves. The nerves of the eyes are irritated, and this irritation in turn is communicated to the nerves of the stomach. The result is seasickness. Car sickness is caused in much the same way.

Abusing the Eye.—Many people are very careless in the treatment of their eyes. Some of the most common abuses are lying down in a strong light or facing a bright light. Reading in a moving train causes eye strain by trying to follow the unsteady type. Moving pictures cause the muscles of the eye to do more work in ten minutes than they would do in a week of ordinary usage.

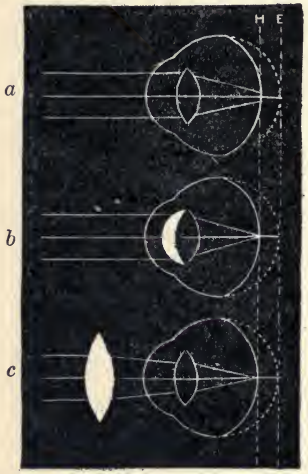


FIG. 230.

FIG. 230*a*.—A far sighted eye at rest. The rays of light meet behind the retina.

FIG. 230*b*—represents rays of light from a distant object focused on the retina by an increased convexity of the lens, the increase being obtained by the muscular effort known as accommodation. In other words, one who has such an eye has to use his accommodation for distant as well as near vision, while the one with a normal eye can save all his accommodation for near work.

FIG. 230*c* represents the error corrected by a convex glass, the necessity for distant accommodation removed and accommodation reserved for near vision.

Alcohol and tobacco may have very injurious effects on the eyes. Tobacco smoke is very irritating to the lids and to the delicate outer covering of the eyeball.

Objections to Wearing Glasses.—Many people object to wearing glasses because they make them look old. If one has any trouble with his eyes, he should go to an eye specialist and be properly fitted to relieve the trouble; this saves a great deal of suffering for the present, and possibly permanent injury to the eyes which cannot be corrected later.

Varieties of Lenses.—Lenses are of three kinds:

1. Spherical. } Convex or Concave
2. Cylindrical.
3. Prismatic. - plain or ground

The spherical and cylindrical are either convex or concave, while the prismatic may be plain or may be ground concave or convex. Any two or three of them may be combined together into one lens.

Oculists and opticians usually indicate the convex lens by a plus sign and the concave lens by a minus sign. The focus of the lens is measured by a unit known as a "diopter." A lens of one diopter has a principal focus one meter in length. (About 39 inches.) A

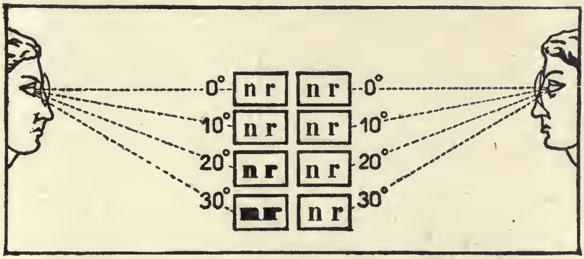


Fig. 231.—The range of perfect vision through a flat lens on the left and a meniscus lens on the right.

lens of two dioptries would mean a focus of half a meter, and so on. Thus a lens marked +3D signifies a convex lens of 3 dioptries, and a lens marked −3D signifies a concave lens of 3 dioptries.

In far-sighted eyes the rays of light tend to meet behind the retina, but by the use of a **convex** lens placed before the eyes they can be made to meet on the retina. (Fig. 230.)

Near sightedness is caused by the rays of light meeting at a focus in front of the retina. Concave lenses placed before the eyes cause the rays of light to spread and again meet further back on the retina. The lens must be more or less concave according to the individual need. (Fig. 226, 227.)

Flat and Meniscus Lens.—There are two types of lenses used for the eye. One is called the flat lens and the other is the meniscus.

FIG. 232.—Picture of church taken through a +8D flat lens.

FIG. 233.—Picture of church taken through a +8D meniscus lens.

People who wear flat lenses must look through the center of the lens to make objects appear clear and sharp. This, undoubtedly, is the reason why people turn their heads frequently when wearing glasses, or look over the tops of their glasses. The eyes are not stationary. They rotate in their sockets, and one moves them across the printed page, or whatever the field of vision may be, without moving the head. A person wearing flat lenses will notice a hazy and distorted appearance at the margin of the lenses. Either the object is magnified too much or too little. The optical scientist calls this astigmatism and distortion.

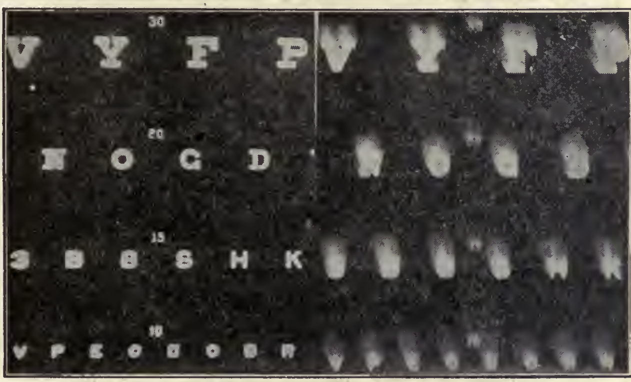


FIG. 234.—These illustrate the effect of looking obliquely through a lens. The clear one was taken with the lens in its proper position; the second with the lens tilted so that the light from the letters passed obliquely through it. Lenses worn on a tilt cause eye strain.

Fig. 232 will show the effect of photographing a church through a strong flat eye lens which was used in place of a camera lens. With the meniscus lens a different kind of picture was obtained, as shown in Fig. 233.

The meniscus lens has spherical surfaces. It is called toric if one surface has two different curvatures. The use of this lens allows a clear image to be seen at almost any angle to which the eyes are shifted, without moving the head, thus allowing a more normal vision. Sometimes the superiority of the deep curved lens is claimed

to be its closer conformation to the shape of the eyeballs. This is untrue.

Protect the Eyes.—Too much light, as well as too little, should be avoided. A "soft" light of sufficient strength to afford easy vision without fatigue to the eyes is the ideal illumination.

Avoid severe contrast. For example, a brilliant light against a dark background is injurious to the eyes.

Bad position; light shining in the eyes, direct reflection from book, chest contracted.

Good position; eyes shaded, no reflection from the paper, chest expanded.

Fig. 235.

Lamps should be so placed or shaded as to prevent the eye being exposed to bright light sources.

The source of light should never be in front of a person who is reading. The light should fall over the shoulder or come from the side.

Lamps should be so placed or shaded that the rays falling on a glazed or polished surface will not be directly reflected into the eyes. Books with very shiny paper surfaces often produce injurious effects by reflecting too much strong light into the eyes.

The Iris.—The colored part of the eye is called the **iris.** Its function is to regulate the amount of light that enters the eye. The circular opening in the center of the iris is called the **pupil.** Circular muscular fibers run around the pupil; and when they contract the pupil is made smaller. Other muscle fibers run in from the outer edge of the iris to the pupil; and when these contract the pupil is enlarged. The size of the pupil is under involuntary control. When a strong light enters the eye, the pupil is diminished, while in a weak light the pupil is enlarged to admit more light. It takes a few

Pupil of eye expanded to let in plenty of light when illumination is dim.

Same pupil contracted to shut out excessive light.

Fig. 236.

minutes for the pupil to adjust itself to sudden changes in the quantity of light.

A cat's eyes show very distinctly the changes in the size of the pupil. Examine the eyes of a cat in the light, and after shutting the cat in a dark room examine the eyes again.

Owls have very large pupils which enable them to see at night better than most animals and birds; but a bright light dazzles their eyes, as the pupils can not be made sufficiently small. Many animals, as the cat and horse, can see better at night than man can see, because their pupils can be opened wider than the pupils of the human eye.

Darken the room. Look at the iris of someone's eye. Quickly bring a candle near the eye. Notice how the iris slowly closes.

Fig. 237

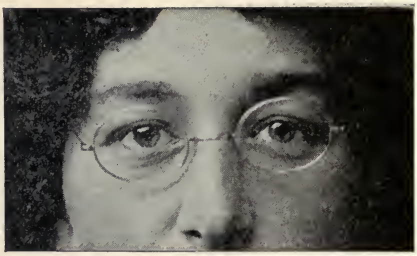


Fig. 238.

Fig. 239.

Fig. 240.

Fig. 241.

Fig. 242.

Fig. 237.—Eyeglasses too large, not properly centered; left lens too low; lenses much too wide apart.

Fig. 238.—Spectacles not properly centered; right lens too low; left lens too high; lenses wider apart than the eyes.

Fig. 239.—Lenses too low and drooping. The outer extremity of each lens should be on a level with the inner extremity. This is especially important when there is any astigmatism to correct.

Fig. 240.—Lenses much too large, otherwise well adjusted. If people with small faces wish to wear disproportionately large mannish lenses under the mistaken impression that they look well, they should have the optician decenter the lenses in the mounting, so that the optical centers of the lenses are the same distance apart as the pupils of the two eyes; then no harm will be done to the eyes.

Fig. 241.—Lenses tipped back at the top instead of slightly forward. This is a common fault, especially with finger-piece mountings.

Fig. 242.—Lenses too far from the eyes, too small and too high; wearer can easily look over or around them.

The Orbit.—The human eye is peculiarly well protected in its bony socket. Nothing but a well-aimed thrust of a comparatively sharp instrument can injure it. Ordinary blows are sure to be received by the prominent cheek-bone below or the edge of the frontal above. It is also protected from shocks by a cushion of soft material. The cavity of the orbit is conical in shape, and the space not occupied by the eye and its appendages is filled with loose tissue containing fat.

The Eyeball.—The eyeball is in the shape of a sphere, with the segment of a smaller sphere grafted upon it, making the diameter from before backward a little greater than the lateral diameter, which is about one inch. The eye is apparently set in a slit in the skin of the face, but really this is not the case, for the skin of the eyelids turns over their edge and becomes here a thin, transparent, smooth, and exceedingly sensitive mucous membrane, the **conjunctiva**, which lines the lids and extends over the front part of the eyeball itself so that the eye is really *behind the skin.*

The Sclerotic Coat.—The eye is a globular receptacle filled with transparent fluids. The walls of the receptacle are three in number, closely attached to each other, and called respectively the outer or first, the middle or second, and the inner or third *tunic.* The outer tunic is in two parts, one opaque, the other transparent. That part which covers about five-sixths of the eye and is of a pearly white color is called the **sclerotic coat.** The part of it which we can see is called the "white of the eye." It is a very tough, dense membrane, rigid enough to give shape to the eyeball, yet elastic and yielding to pressure. The muscles of the eye are inserted into it; and it is perforated at the back part for the entrance of the optic nerve. The existence of nerves in it is doubtful, and its blood-vessels are few in number. The veins we see in the white of the eye when it is "blood-shot" are in the conjunctiva, which is so transparent that we do not see it except when its vessels are filled to excess with blood.

The Cornea.—The cornea is perfectly transparent and fits into the sclerotic coat like the crystal of a watch in its case. In outline it is almost circular. The conjunctiva covers it in front. It contains numerous nerves but no blood-vessels. The cornea

is the window through which light enters the interior of the eye.

The Choroid Membrane.—The middle coat of the eye which lines the sclerotic coat is called the choroid membrane. Like the sclerotic it is pierced behind for the entrance of the optic nerve.

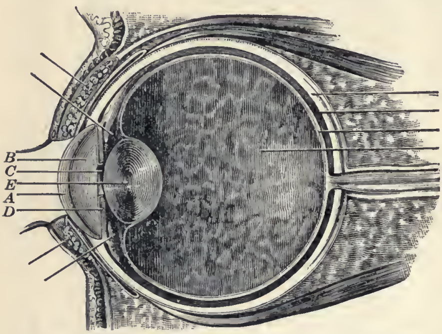


FIG. 243.—A Section of the Human Eye. *A*, cornea; *B*, aqueous humor; *C*, pupil; *D*, iris; *E*, crystalline lens; *K*, vitreous humor; *L*, optic nerve; *F*, Sclerotic; *G*, choroid; *H*, retina.

The Aqueous Humor.—The cavity of the eye is filled by three transparent bodies, called humors. That occupying mainly the space behind the cornea and in front of the iris is called the aqueous humor. A very little of it lies in the space behind the iris, communicating with that in front through the pupil. It is a clear liquid, consisting mostly of water with alkaline salts in solution. If the cornea be punctured the aqueous humor escapes, the protuberant part of the eye collapses, and the sight is temporarily lost. The wound will, however, heal in a short time and a new supply of liquid will be secreted and sight restored.

The Vitreous Humor.—The large cavity enclosed mainly by the retina contains a thick, jellylike transparent albuminous substance, called the vitreous humor.

The Protectors of the Eye.—Not only is the eye well protected by its location, but it has in addition certain guards and defenders. The eyebrows shield it from excessive light and direct the perspiration to one side and possibly catch some particles of dust that otherwise would get into the eye. The eyelids, composed of a piece of cartilage covered with skin and lined with the mucous membrane, act both reflexively and voluntarily, closing instantly when danger approaches. Their edges contain small glands (Meibomian glands) which secrete an oily fluid which prevents the tears from overflowing on the face and keeps the lids from

growing together. The **cilia,** or **eyelashes,** act as shades to the eye and as feelers to warn of danger in the dark. The **conjunctiva** has already been described. Being highly sensitive it warns us of the danger of permitting particles to remain in contact with the eye.

The Lachrymal Apparatus.—This is an additional means of protection to the eye, and consists of the lachrymal gland, with excretory ducts, the lachrymal canals, the lachrymal sac, and nasal duct. The lachrymal gland is located in the upper, outer part of the orbit, and pours its secretion through several ducts upon the eyeball. The constant winking keeps it distributed over the eye. It is prevented from flowing off upon the face, unless in excessive quantity, by the oil from the Meibomian glands. The orifices of the two lachrymal canals open at the inner corner of the eye and receive the fluid. They empty it into the lachrymal sac, and this discharges it into the nasal duct which opens in the nasal cavity. Here it evaporates as fast as discharged. When the secretion is excessive it flows over the lids down the face in the form of tears. The tears consist mostly of water containing salts in solution, common salt, or chloride of sodium, being most abundant. The use of the lachrymal fluid is obvious. It maintains the clearness of the eye by keeping it moist, and washes dust and foreign particles away and protects the delicate mucous membrane from the irritating effect of the air.

Experiment.—Secure from the butcher the eyes from an ox, pig, or sheep. If possible get several specimens to use in case one is spoiled in dissection, and also that you may try different methods of preparing them for illustration. Place in water until ready for use. With the aid of Fig. 243 examine each part of the eye. Notice that the crystalline lens if placed over print will magnify the words.

Position of the Eyes.—Animals are divided into two classes as to the position of their eyes.

1. All hunted animals have side eyes, or, in other words, their eyes are placed on the sides of the heads, which enables them to look in opposite directions for approaching danger.

2. Hunting animals have front eyes, since such animals hunting for food must have eyes for looking directly ahead.

Why We Have Two Eyes.—Some have said the reason we have two eyes is because nature has provided an extra eye if one of the eyes is injured. This, however, is not true. With two eyes we are able to judge distances more accurately. If you close one eye and try to judge distance, it is very difficult. The eyes do not see from the same point of view. This produces perspective and gives objects depth. An instrument called the stereoscope is used to give a very clear three-dimensional picture of places and buildings. This is obtained by taking two photographs of the same object from two different points corresponding to the eyes.

If you close one eye, and try to insert a pencil in a hole it will be almost impossible to accomplish the task at the first trial. But the two eyes focus together, producing the image we are accustomed to, for each eye sees the object from a different point.

By looking simultaneously with two eyes we see an object from two slightly different directions, and, when the images made by the two eyes are blended into one sensation in the brain, we get the effect of depth or solidity which makes objects appear to stand forth free from their background. In other words, the eyes give a perspective to things which would otherwise appear flat.

Hold your hand at arm's length before you and look at it with only one eye open. It will appear to lie against the wall of the room; if it does not actually appear to do so, it is because you know that it is nearer to you than the wall. Open both eyes and notice the change. Notice that the hand stands forth in space far in front of the wall. Look at the hand first with one eye, then with the other, and notice how each eye perceives the hand in a different direction against the wall.

The Blind Spot.—Where the optic nerve enters the retina a blind spot is produced. The most sensitive spot on the retina is called the yellow spot, and is slightly removed from the place where the optic nerve enters the eyeball. By closing one eye and looking at the cross in the illustration, gradually bringing the book toward the face, the round spot will disappear. Fig. 247. The image of the dot is now on the blind spot of the eye, just where the optic nerve is not sensitive to light. If the book is brought a little nearer to the face the black dot will again be seen.

Why We See Objects Upright.—You have noticed from all experiments that the image made by a convex lens is always inverted; since the crystalline lens of the eye is a convex lens, the image formed on the retina will be reversed. The sensation produced by the image on the retina is conveyed into the brain by the optic nerve. It is not the image but the object from which the rays of light come, forming the image, on which the eye depends for an impression; and since the eye deals with the outside object, and depends upon the inside image for the sensation, the impression made on the brain is that of the real object which is upright. If, however, we look at the image formed by a convex lens the image is inverted. Again, the eye is dealing with the object outside of the eye, which, in this case, is an inverted image formed by a convex lens. The sensation given to the brain is an inverted image which is the actual object outside the eye.

Optical Illusions.—The sense of sight is liable to errors and illusions. A few interesting examples will show how a person may be deceived through the sense of sight. In the illustration the white square will appear larger than the black one. Fig. 249.

A vertical line which is thin will seem longer than a thick horizontal line of the same length.

People dressed in white look larger than when dressed in black. Another interesting illusion is taken advantage of in decorating rooms and in the selection of dresses.

If two perfect squares be made, one of horizontal lines and the other of vertical lines, the space covered by one set seems to be greater than the space covered by the other set of lines.

Stout people should not wear dress goods having horizontal stripes, and slim people should avoid dress goods with vertical stripes.

Other optical illusions may be produced by crossing two parallel lines with a series of oblique lines as shown in the illustrations.

An interesting optical illusion may be produced by looking through a paper tube with one eye, and holding a hand near the tube. If the other eye is open, objects appear visible through an apparent hole in the hand.

The poet was perfectly right when he said that things are not

Fig. 244.—If you fix your eyes on the two white spaces between the lines the top space will seem to become wider at the ends, and the bottom space wider in the middle. But both are perfectly straight.

Fig. 245.—Which line is the longer? The black line on the right appears longer than the line beside it, but both lines are exactly the same length.

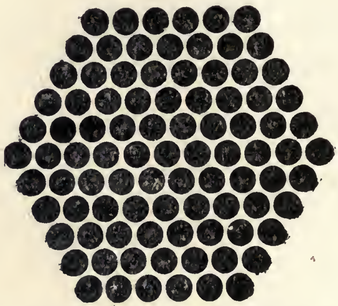


Fig. 246.—This shows how a circle appears to have sides and corners. These black spots, if looked at intently, seem to have six sides, like a honeycomb, but they are all quite round.

Fig. 247.—There is a blind spot in both your eyes—that is to say, part of the eye is blind. You can prove this by closing your left eye and looking at the X with your right. Hold the paper a foot away and then draw it towards you. While looking at the X you will see the spot too, but at a certain point the spot will disappear. By drawing it still nearer to you you will bring the spot into view again.

FIG. 248.—Who is the biggest? The policeman most people would say. But the policeman is really the smallest, and the little girl is the biggest.

FIG. 249.—Which square is the larger? Most people would say the white, but the white is the same size as the black.

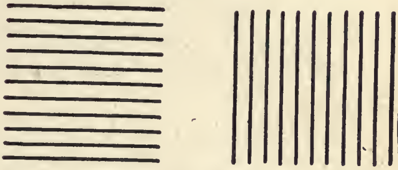


FIG. 250.—One of these sets of lines looks higher than it is wide, and the other wider than it is high, but both are square.

FIG. 251.—Turn the page round and round to the left. The plain rings will appear to revolve rapidly to the left, and the others to go slowly round in the opposite direction.

always what they seem. We cannot always believe our own eyes. Our vision of things is never quite perfect. There is always a little error in our sight, and this page shows us how we may deceive our eyes and make them believe that things are not what they are.

Questions

1. Why are lenses necessary for people who are near or far sighted?

2. Name some diseases which may be traced to defective eyes.

3. Why are images formed on the retina of an eye?

4. Why is it possible to focus so as to get an image of distant and near objects?

5. Why should people be very careful to have their eyes tested?

6. How could one test for near and far sightedness?

7. How is it possible to test for astigmatism?

8. Why are people sometimes car-sick?

9. How do people often abuse their eyes?

10. What kind of lens is necessary to correct short sightedness? Why?

11. What kind of a lens is necessary to correct far sightedness? Why?

12. What is the advantage of the meniscus lens over the flat lens?

13. What kind of light is best for the eyes?

14. What kind of light should be avoided?

15. How should lamps be placed for general use?

16. Why do owls have difficulty in seeing during the day?

17. Why do they see so well during night time?

18. Why does the house seem to be very dark after coming in from outdoors where the sun is shining brightly on snow or sand?

19. Do two eyes allow more light to enter than one eye? Give reason for your answer.

20. Why is it necessary to have two eyes?

21. Why is the place where the optic nerve enters the eyeball called the blind spot?

22. Name some of the advantages of optical illusion which are employed in dress?

23. Should stout or thin people wear bow ties? Why?

24. What kind of people should wear four-in-hand ties?

ILLUMINATION

Method of Illumination.—Illumination should be by transmitted, dissipated, and reflected light. If the light is glaring and too bright, it blinds the eyesight. Not only is the decorative value of a room destroyed but the sense of comfort and repose is lacking in offensive white light.

Amount of Illumination.—The well-known sleepiness of church-goers of olden times was often due to eye fatigue from the harsh light in front. Many people suffer from theater headaches and moving picture headaches for the same cause.

Sleepiness comes on very readily when reading by artificial light because of eye strain brought about by the light used. The brilliancy of any light should not exceed 4 to 5 candle power per square inch, and may be as low as from $\frac{1}{10}$ to $\frac{2}{10}$. One should never read in any light which causes discomfort to the eyes.

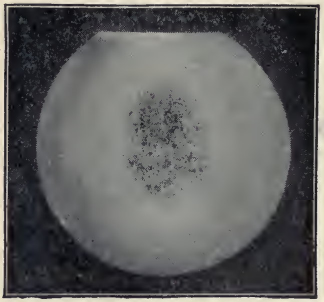
The following table will give some idea as to the amount of brilliancy in candle power per square inch of some of our methods of lighting. Bear in mind that the safe range of candle power for comfort is from 1 to 5 candle power per square inch.

Source of Light.	Candle Power per Sq. In.
Candle	3 to 4
Oil Lamp	3 to 8
Gas Flame	3 to 8
Welsbach gas mantle	20 to 50
Carbon filament light	375 to 400
Tungsten electric light	1000 to 1500

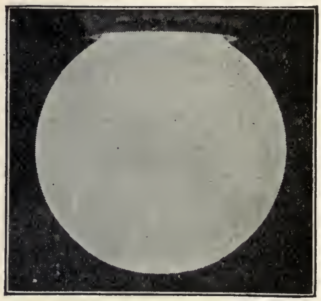
Direct Lighting.—When the rays of light from a lamp are reflected in one general direction, usually downward, it is said to give direct light. This is accomplished by the use of a dense shade of metal, glass or silk. The usual type of reading lamp is an example of direct lighting.

Semi-direct Lighting.—Sometimes translucent reflectors which permit some of the rays to pass through upward, yet reflect the majority of the rays downward, are used. Whenever reflectors of this type are used, semi-direct lighting is produced.

Indirect Lighting.—Whenever a light is equipped with an opaque or partially opaque bowl reflector, and the rays of light are directed upward to be reflected back by a white ceiling, the room is lighted



Ground glass globe.



Opal Glass Globe.

FIG. 252.—Within each globe is a lamp of the same candle-power. Note the superior diffusion of the light by the opal globe.

by indirect light. This form of light is often considered the best, since it lights the entire room and relieves the eyes from all strain.

Semi-indirect Lighting.—Translucent bowl reflectors which allow some of the rays of light to pass through, but reflect the majority

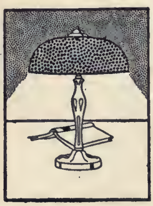


FIG. 253.—Direct light.

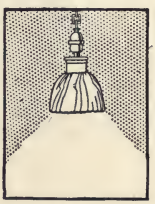


FIG. 254.—Semi-direct light.

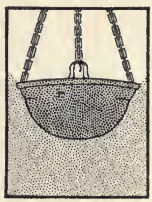


FIG. 255.—Indirect light.

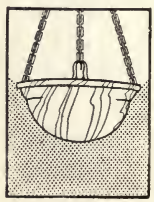


FIG. 256.—Semi-indirect light.

of the rays of light upward to be reflected back by the white ceiling, are often used to produce semi-indirect lighting.

Light Transmitted through Various Colors.—The amount of light transmitted through colored glass is quite important if shades are used in the home. Less light is transmitted through red than through green. Red lights have always been the danger signal on

railroads and elsewhere, although it is really a poor color for this purpose. Pure, deep red allows so little light to pass through that

Bust lighted from above and in front. The same bust lighted from directly overhead.

FIG. 257.—Bad lighting defeats good art.

it is impracticable. Green would have been the better signal for danger, since it can be more easily seen than red.

Material.	Per Cent of Transmitted Light.
Clear glass	100
Canary	82
Ruby	13.1
Bottle green	10.6
Bright green (signal green No. 2)	19.4
Bluish green (signal green No. 2)	6.9
Cobalt blue	3.7

For ordinary illumination white or yellowish white is desirable. Blue or green tinges in the light give a cold, hard hue to objects in general, and also give an unnatural pallor to the face.

The light from the moon on a clear night is an example of a "cold light." Such lights give rooms a bare, chill, and unfinished appearance.

Strong red light is harsh and trying. A yellow or orange tinge in the light softens and brightens the interior.

Globes, Shades and Reflectors.—It is usually customary to equip lamps with reflectors of some form of glass or other reflecting medium to diffuse and direct the light in the most useful directions. The following diagrams illustrate the distribution of light from a

Bare Lamp Distribution. Extensive Distribution. Intensive Distribution Concentrating Distribution.

FIG. 258.

bare lamp, and also the distribution effected when the lamp is equipped with different types of reflectors. Our homes should be equipped not only with artistic reflectors but with such a type of reflector that the maximum useful illumination will be obtained at the smallest cost.

Lamps, reflectors and shades should be kept clean, as dirt and dust absorb light and thereby reduce the volume of illumination.

Color of Glassware.	Loss by Absorption, Per Cent.
Clear glass globes	5 to 12
Light sand-blasted globes	10 to 20
Alabaster globes	10 to 20
Canary-colored globes	15 to 20
Light blue alabaster globes	15 to 25
Heavy blue alabaster globes	15 to 30
Ribbed glass globes	15 to 30
Opaline glass globes	15 to 40
Ground glass globes	20 to 30

Color of Glassware.	Loss by Absorption, Per Cent.
Medium opalescent globes	25 to 40
Heavy opalescent globes	30 to 60
Flame glass globes	30 to 60
Signal green globes	80 to 90
Ruby glass globes	85 to 90
Cobalt blue globes	90 to 95

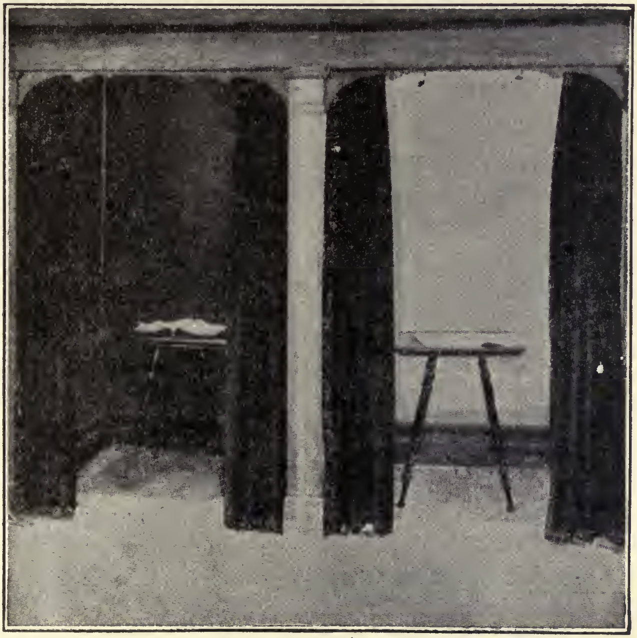


FIG. 259.—Each of these two little rooms receives the same light. Dark walls absorb most of the rays of light in the left-hand room.

Color of Walls.—The color of the walls of a room is a very important matter. If the color is one that reflects light, instead of absorbing it, less illumination will be required and the cost of the lighting will be lessened.

In school rooms the wall space occupied by blackboards causes

much loss of light. It has been proved that a light buff tint is the most satisfactory color for the walls of a school room. Dark-colored woodwork and furniture with natural dull finish help to reduce the reflection of light. Unvarnished surfaces, however, are so difficult to clean thoroughly that for this reason the woodwork is usually varnished.

Smooth paper and paint reflect much more light, regardless of the color, than a silky finish. Dirty paper, of course, reflects much less light than clean paper. The following table will give some idea as to the amount of light different materials reflect.

Material.	Per Cent of Diffuse Reflection.
White blotting paper	82
White cartridge paper	80
White cardboard	74
Ordinary foolscap	70
Chrome-yellow paper	62
Cream paper	56
Light-cream paint	52
Light-orange paper	50
Pale-green paint	45
Plain deal (clean)	45
Yellow wall paper	40
Yellow painted wall (clean)	40
Light-pink paper	36
Yellow cardboard	30
Light-blue cardboard	25
Brown cardboard	20
Plain deal (dirty)	20
Yellow-painted wall (dirty)	20
Light emerald-green paper	18
Dark-brown paper	13
Vermilion paper	12
Blue-green paper	12
Cobalt-blue paper	12
Dark-green paper	05
Maroon paper	05

Material.	Per Cent of Diffuse Reflection.
Black paper	05
Deep-chocolate paper	04
French ultramarine-blue paper	03.5
Black cloth	01.2
Black velvet	00.4

Effect of Light on Fabrics.—We all know how hard it is to match colors by night. The reason for this may be seen in the following table of colors, and the table of colors of lights. It must be remembered that this is only a general table, and that some of the delicate shades of modern dyes may reflect and absorb light in a very strange way

Original Color of Fabric.	Color of Light Falling Upon Fabric.*					
	Red.	Orange.	Yellow.	Green.	Blue.	Violet.
Black	Purplish black	Deep maroon	Yellow-olive	Greenish brown	Blue-black	Faint violet-black
White	Red	Orange	Light yellow	Green	Blue	Violet
Red	Intense red	Scarlet	Orange	Brown	Violet	Red-violet purple
Orange	Orange red	Intense orange	Yellow-orange	Faint yellow, slightly greenish	Brown slightly violet	Light red
Yellow	Orange	Yellow orange	Orange-yellow	Yellowish green	Green	Brown tinged with faint red
Light green	Reddish gray	Yellow green	Greenish yellow	Intenser green	Blue-green	Light purple
Deep green	Reddish black	Rusty green	Yellowish green	Intenser green	Greenish blue	Bluish gray
Light blue	Violet	Orange gray	Yellowish green	Green blue	Vivid blue	Violet blue
Deep blue	Violet-purple	Gray' slightly an orange	Green-slate	Blue-green	Intenser blue	Bright blue violet
Indigo blue	Purple slightly violet	Orange-maroon	Orange-yellow	Dull green	Dark blue indigo	Deep blue violet
Violet	Purple	Red-maroon	Yellow-maroon	Bluish green-brown	Deep bluish-violet	Deep violet

* " Art of Illumination."—Bell.

Variation in original color produced by the use of various colored lights is often taken advantage of for lighting scenes on stages. It is often impossible to tell the real color of the dress of an actress, or to match material by artificial light.

The following types of illumination used with the above table will give some hints as to why materials have different colors under different lights.

Illuminant.	Color.
Sun (high in sky)	White.
Sun (near horizon)	Orange red.
Skylight	Very bluish white.
Electric arc (short)	White.
Electric arc (long)	Bluish white to violet.
Flame arc	Commonly, yellow.
Mercury arc	Bluish green.
Nernst lamp	Yellowish white.
Tungsten lamp	Yellowish white.
Incandescent (normal), carbon	Yellowish.
Incandescent (below voltage), carbon	Orange to orange red.
Acetylene flame	Yellowish white.
Welsbach light	Yellowish to greenish white.
Gaslight (Siemens burner)	Whitish yellow tinge.
Gaslight, ordinary	Yellowish to pale orange.
Kerosene lamp	Yellowish to pale orange.
Candle	Orange yellow.

Amount and Position of Window Space.—For proper lighting of rooms the amount of window space should be about one-sixth to one-fourth of the floor space.

The bottoms of all windows should be higher than the eyes of students studying in a classroom, to prevent direct light shining in the eyes of pupils.

Windows should extend to or nearly to the ceiling of the room. Light should enter one side of the room only, especially in school rooms, to prevent a student facing the light to see the blackboard, or when the head is turned to either side. The light from the windows must never fall in one's eyes. Sunlight should be reflected

from the object we are looking at, and, in most cases of sunlight, indirect sunlight should be reflected from the object to one's eyes.

Windows should never be built in the rear of a school room unless to obtain a good breeze during hot weather. Such windows ought to be very high—at least 8 feet above the floor so—that all light be reflected toward the ceiling. It is better to have such windows hinged at the bottom and covered with an opaque shade. The window can then be dropped to allow air to enter without allowing light to fall from the back directly on students. Such windows are sometimes called "breeze windows." South light is bad since direct sunlight is obtained during a great part of the day. Too much direct light often irritates and tires people.

If windows are located on the east side, early morning light enters the room, purifying the air. After ten o'clock in the morning indirect rays of light enter, since the sun has moved to a position in the heavens whence no direct light can enter the windows.

Rooms which face the west, especially school rooms, are often desirable since the direct sunlight does not enter the room until after school hours. If the sun does begin to shine into the room in the early afternoon, the room becomes very warm and uncomfortable during hot weather.

North light is unsatisfactory because little sunlight enters the room at any time of the day. Hence, the room, although cool in summer, has little of the purifying influence of the sun.

Windows Shaded by Buildings.—Buildings are sometimes very close to each other, producing dark rooms. This has been largely overcome by the use of ribbed or prism glass which diffuses the light throughout the room. In many modern school houses this glass is used at the top of the windows. Basements, dark halls, and dark rooms may be easily made lighter by the use of ribbed glass. Very frequently shop windows and store windows are provided with this type of glass to obtain better illumination during the day.

Questions

1. Why is it impossible to look directly at the sun?
2. Why do dark glasses assist us in looking at the sun?
3. How should we sit with reference to the light when we are reading?

4. Should seats be so arranged as to have the light come from the left side or from the right side? Why?

5. Why do rooms lighted by indirect light have very few, if any, shadows?

6. In what part of a room is it better for a teacher to stand when talking to her pupils—before the window, or on the opposite side of the room from the window?

7. Why does a blow on the head make one see stars, especially when delivered upon the back of the head where the brain is excited by the optic nerve?

8. Why is it difficult to see out of the window at night from a lighted room?

9. What kind of lights do you use in your home?

10. How many candle power per square inch of light do you obtain?

11. How much more is this per square inch than the correct amount per square inch?

12. What warning has a person that the light is too bright?

13. What kind of lighting system is best for a home?

14. Why should a stage hall never be brilliantly lighted?

15. Why are red lights bad danger signals?

16. What kind of shades should be used for lights in halls?

17. What is the best kind of shade used in a home?

18. Why should paper be often cleaned in rooms which are not well lighted by windows?

19. What kind of paper is best for living rooms?

20. What happens when deep green and light blue are placed in a yellow light?

21. What would be the color of red under a mercury arc, Tungsten lamp, an electric arc (long)?

22. What would be the effect of light green under the same lights?

23. Why is light blue hard to match by a mercury light?

24. What would be the effect on light green material if placed in a room lighted by incandescent carbon lamps?

25. What color would a red dress look on a stage if yellow light were thrown upon it? A blue light? An orange light?

26. How much window space has your school room as compared with the floor space?

27. Determine the proper amount of window space for your living room, dining room, etc., at home.

28. What kind of light is best for studying?

29. Why is direct sunlight injurious for studying?

30. How much above your eyes is the window when you are studying?

31. Because of danger from fire some have opposed the building of the bottoms of windows higher than the pupils' eyes. Why is this objection a poor one?

32. Why should primary grade children always have rooms on the bottom floor?

33. Have you any "breeze windows" in your school room? If so, are they properly protected?

34. At what time of the day does direct light enter the room where you study?

35. At what part of the day do you have ndirect light in your school room?

36. At what parts of the day do you have direct and indirect light from the sun in your living rooms at home?

37. Why do some rooms appear darker than others with the same amount of light entering?

38. Why should rooms be well lighted with sunlight?

39. Why is it possible to light rooms by sunlight even though the sunlight does not come directly into them?

40. What causes the wavy appearance over a hot stove or over a sandy beach during a hot day?

41. What part of this section is of greatest importance?

COMPUTING THE COST OF LIGHTING

Measurement of Lights.—Lights are measured by candle power. As the words suggest, a light of a certain candle power means the number of times more light that particular light gives than a candle. Standard candles are used for this purpose. To say a lamp has a candle power marked sixteen (16) means that that light will give

sixteen times as much light as a standard candle. It is usually customary to say that if a candle is placed one foot from a surface the amount of illumination received by it is called **one foot candle.** If the distance is increased, the illumination decreases in proportion to the square of the distance. Hence, at two feet the one candle would give only one-fourth ($\frac{1}{4}$) foot candle power, and a sixteen (16) candle power lamp would give at two feet one-fourth of sixteen ($\frac{1}{4}\times16$) or four foot candles.

The reason for this is very plain. It is simply that the same amount of light is spread over a greater and greater surface. As the distance is increased, the light which falls on one square foot at

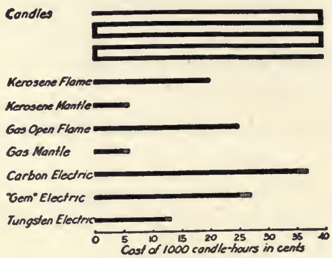


FIG. 260.—How many times more expensive would it be to light a house with candles than with electricity? Compare the cost of lighting with different kinds of electric lights and gas light. What would be the difference between gas and electricity? What method of lighting by gas is the cheapest? What method of lighting by electricity is the cheapest?

one foot distance must, at two feet, illuminate a surface which is two feet on a side; that is, four square feet. At three feet distance, the light is spread over nine square feet, and so on. Therefore, the amount of illumination that each square foot will receive will be the square of the distance inverted.

Measuring Candle Power of a Lamp.—The candle power of a lamp may be roughly measured by placing a white piece of cardboard upright on the table and sticking a pencil in a piece of cork so that it will stand upright about 2 inches from the paper. Place a candle about 1 foot distant from the pencil. Place the lamp far enough back so that the shadow caused by the candle will be of the same density as the shadow caused by the light. If the distance

from the light to the screen be squared and divided by the distance of the candle from the screen squared, the candle power of the light may be obtained.

Cost of Light.—There are many different types of lights on the market. Some of them produce light at a very low cost, but others produce light at a very great cost.

Fig. 260 will show the comparative cost of different materials for lighting. It will be seen that candles are the most expensive, and that gas mantles are much cheaper than the open gas flame or kerosene. However, people may live in localities where it is impossible to obtain the cheapest form of lighting. If kerosene

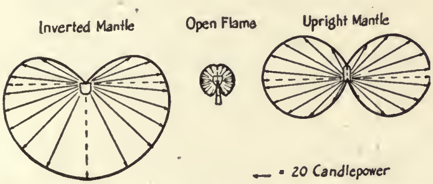


FIG. 261.—Amount of light received from different lights. The same amount of gas used in each case. Why is it cheaper to use mantles than open flame?

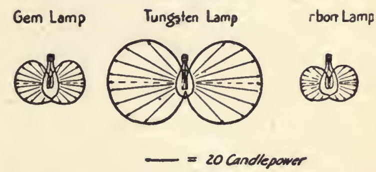


FIG. 262.—How much more light do you receive from a Tungsten lamp than from a carbon lamp if the same amount of electricity is used in each case?

only can be used, the kerosene mantle lamp is very much cheaper than the ordinary kerosene lamp.

Use of Mantles.—Wherever mantles can be used, they make it possible to obtain the same amount of light much more cheaply than by the use of open flames. Usually a mantle will use about one-fourth as much gas in giving the same amount of light as an open flame. In addition to the actual saving in gas, the mantle burners have a great advantage in furnishing a steady light. In some cases, also, there is considerable reduction of the risk of fire, since the mantle burners are protected by chimneys so effectually that inflammable objects cannot reach the flame. There appears to be no good reason for the use of open flame burners in any place unless there are conditions which cause excessive breakage of mantles.

Light Obtained from Electric Lamps.—Of electric lights there are several kinds used in the household: the metalized carbon, called the "Gem," the "Tungsten" lamp, usually known under the name of "Mazda," and the ordinary carbon lamp. Fig. 262 will show the comparison of the amount of light given by different lights at the same cost.

Questions

1. What would be the effect if you were reading 8 feet from a lamp and you moved 24 feet away, the candle power of the lamp being 32?
2. What is the cheapest form of gas light to use?
3. Why are mantles economical?
4. What is the cheapest type of electric light to use?
5. What causes an object to have color?
6. Why is it impossible to match colors in artificial light?
7. How are most of our colored pictures in magazines obtained?
8. Why will a white table cloth on a mahogany table make a room lighter?
9. Why should rooms be well lighted?

COLOR AND CHEMICAL ACTION OF LIGHT

Color.—No object has any color of its own but depends for its color upon the light rays which are reflected by the material. There are three sets of nerves in the retina of the eye; one sensitive to red, another to green, and a third to blue light waves. When all three of these nerves are stimulated equally, white is obtained. If only the red nerves are stimulated, the person sees red; likewise blue and green when the blue and green sets of nerves are stimulated. If one nerve is stimulated more than another, there is an uneven mixture of color sensation. and intermediate colors are produced.

The shade of these colors varies according to the amount of stimulation. Black objects absorb all the light rays. White objects reflect all light rays. If an object appears red, it means that all the light rays have been absorbed except red. The same is true of other

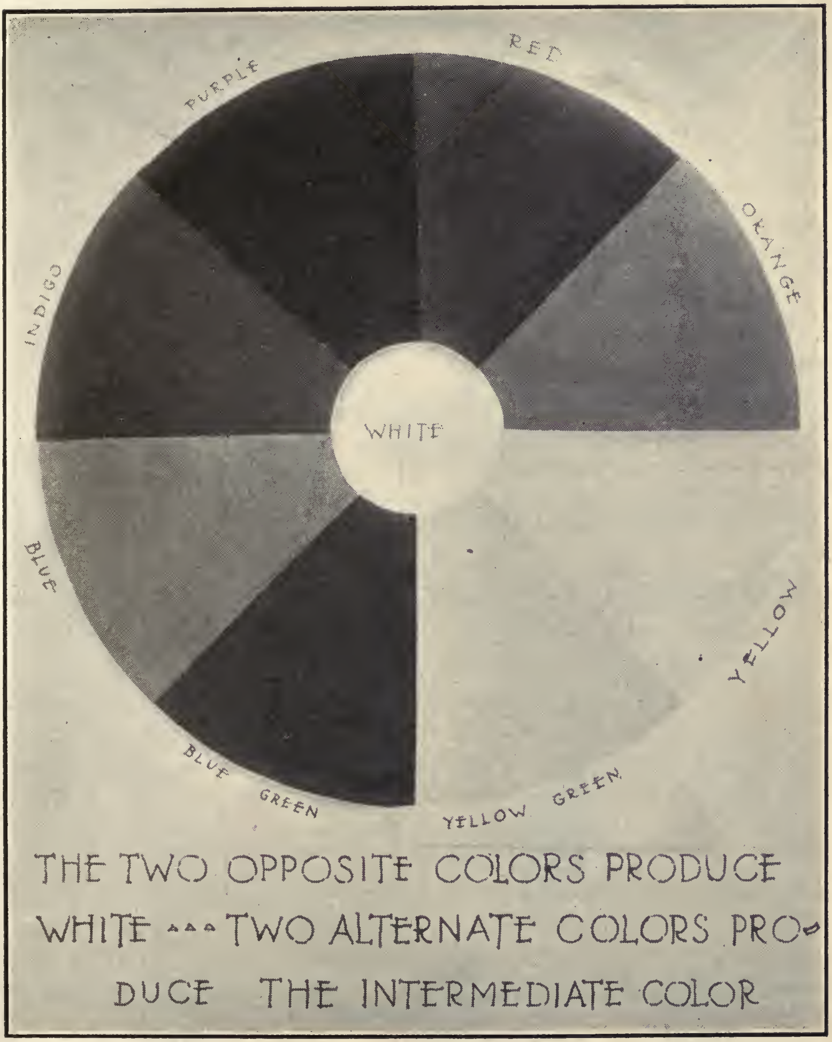

RED
ORANGE
YELLOW
GREEN
YELLOW
GREEN
BLUE
BLUE
INDIGO
PURPLE
WHITE
THE TWO OPPOSITE COLORS PRODUCE
WHITE ... TWO ALTERNATE COLORS PRO-
DUCE THE INTERMEDIATE COLOR

FIG. 263.

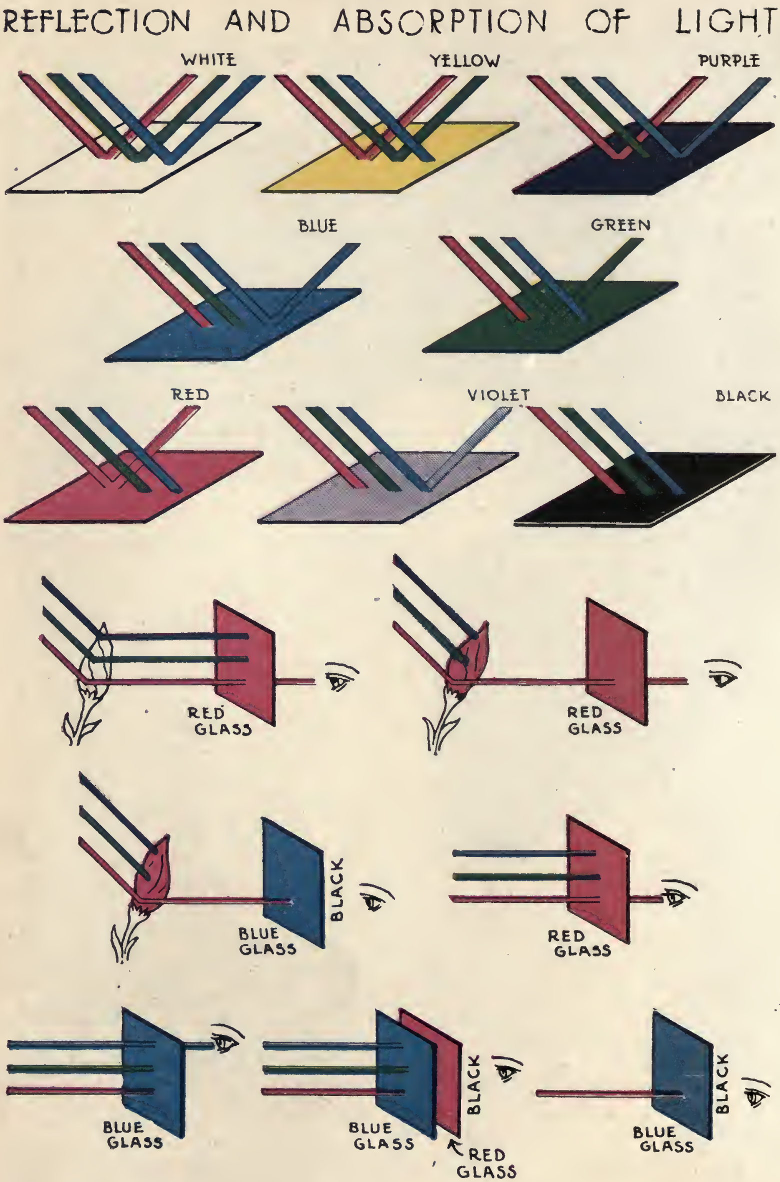

REFLECTION AND ABSORPTION OF LIGHT
WHITE
YELLOW
PURPLE
BLUE
GREEN
RED
VIOLET
BLACK
RED GLASS
RED GLASS
BLUE GLASS
BLACK
RED GLASS
BLUE GLASS
BLUE GLASS
BLACK
RED GLASS
BLUE GLASS
BLACK

FIG. 264.

colors. Prussian blue reflects blue, green and violet light waves. In white light it looks Prussian blue; in green light the material covered with Prussian blue looks green; in violet light, violet. The colors violet and green are not very strong, as not much of this color is reflected.

The color of an object, then, depends upon what light waves it reflects or absorbs. Color is a sensation, and not an object.

FIG. 264.—Color depends upon the light rays reflected. When red, green and blue rays are reflected by any object, the object appears white (Figure on top, left row). When red and green rays are reflected and blue is absorbed the object will look yellow. (Central figure, top line.) What is the effect if red and blue are reflected and green is absorbed? What causes a substance to look blue? (First figure left, second row.) What causes a book to appear green? When will cloth look red? When will paper look black? What color rays is a white rose reflecting? What color will a white rose look if viewed through a red glass? Why? What color ray is a red rose reflecting? What happens to the other two rays? Why does everything look blue through a blue glass? Why do things look black through a red and a blue glass? What happens when red objects are viewed through blue glasses?

Color Blindness.—Sometimes one of the sets of color nerves is lacking or much weakened in a person. This causes a yellow object to appear green to a person lacking the red nerve set, since yellow is a combined effect produced by the stimulation of red and green nerves. Engineers of a railroad must be tested to be sure that they do not lack the red set of nerves, since red is the danger signal. Color blindness may be the cause of many people wearing a combination of colors which is not pleasing. Men, as a rule, are affected more than women with color blindness.

Color Printing.—Many colors are produced to-day by mixing colors in impressions. The colors used are yellow, red and blue. Sometimes black is also employed. Many of our colored pictures are produced by this process.

Chemical Action of Light.—The chemical action of light is used in photography. The light rays reflected from the image are caught by a lens in a camera, and an image is produced on sensitive plates or films. Developing produces on these an image called a negative, from which positives or photographs may be obtained.

Project.—Have one member of the class explain how pictures are tal.. negative, positive, developing, and printing.

Experiment to Show the Chemical Action of Light.—Blueprint paper is often used by architects and draftsmen for printing diagrams. With a camel's hair brush carefully paint a piece of glazed or shiny paper with the solution given on this page. Do this in the dark or before a red light. Place the paper in a drawer or some dark place to dry.

Place a piece of some opaque object over the blueprint paper after it has dried in a dark room, and expose the paper to the sunlight for a minute. Wash thoroughly in water. An image will form on the paper. Be sure that the paper is thoroughly washed so that no yellow stains are left. Try some of the paper with a negative which you may have at home.

Blueprint Solution.

Solution A: Ferric ammonium citrate (brown), 80 grams; water, 1 ounce.

Solution B: Potassium ferricyanide, 60 grams; water, 1 ounce. Do not mix until ready to use. Keep in the dark; mix equal portions of A and B; filter before using.

Another solution may be made by:

Solution A: Ferric ammonium citrate (green), 110 grams; water, 1 ounce.

Solution B: Potassium ferricyanide, 40 grams; water, 1 ounce. Mix and use as above.

Be sure not to use potassium ferrocyanide. The potassium ferricyanide should be in clear ruby red crystals; if otherwise, rinse with water and dry between blotting papers before weighing.

The solutions may be made more sensitive by adding a few drops of oxalic acid. The solutions also keep better if one-half gram per ounce of potassium bichromate is added to the mixed solution.

Chemical Action of Light in Nature.—It is believed that the ultra-violet ray is the agent which changes water and carbon dioxide into starch in the leaves of plants. Probably the coat of tan so often obtained at the seashore is due to the ultra-violet ray. Physicians are treating some diseases with this ray.

Light is the most powerful germicide known.

Questions

1. Why do yellow and blue crayon powdered together look green; red and yellow crayon powdered together look orange?

2. Why are some blues and greens indistinguishable from each other by candle light?

3. Why is it preferable to select colored material by daylight? (When you wish a perfect match, the test should be made both by daylight and by artificial light.)

4. Why do street lights, when viewed through a wire screen or a thin silk curtain, appear to have rays in four directions fringed with rainbow colors?

5. Why may the color of a dewdrop on which the sun is shining be made to change by changing the position of the head?

6. Why do people look ghastly in the light of the flaming arc?

7. Why is the sun red at rising and at setting?

8. Why is the foam of a muddy street white?

9. In the peacock's tail, and on many butterflies where brilliant colors are seen, there is no coloring matter in the feathers or scales. Explain this.

10. Why does a blue sky look green when viewed through yellow glass?

11. Why do you see a bluish-green light if you turn your gaze toward a white wall after looking steadily at a bright red light?

12. What is an " after image "? What causes it?

13. Why does blue cloth look nearly black in gas light?

14. Why is snow white?

15. Why is foam white?

16. Why is the ocean blue?

17. Why does molasses candy whiten on being pulled?

18. What part of this chapter is of greatest value to you? Why?

19. Make a list of the important things in the order in which you consider them of value to you.

Radiograph of an arm injured near Spottsylvania Court House in 1864. Picture taken in 1908, showing injury to bones and 150 pieces of shot still in the arm.

CHAPTER XI

ELECTRICITY

USE OF ELECTRICITY IN THE HOME

Measuring of Electricity.—The gas supplied to a home is measured in cubic feet. This gas is consumed, and the products of combustion escape into the atmosphere. Electricity, however, is not consumed, but merely flows through the lamps, motors or other appliances, and passes back to its source, the electrical generator. We really, then, do not use electricity, but simply the energy which the moving electricity possesses. This energy is sufficient to produce light, heat and power by allowing it to flow through a lamp, a heating device, or a motor. Electricity may be compared to water circulating through pipes.

Suppose in some centrally located place there were a station provided with a large water pump which pumped a supply of water to the buildings of the town. Assume that all the water of that place was used to run through some type of machine, such as a motor, and that all the water, instead of running into a sewer, was drawn back through another pipe to the pump and then sent out again. The water would be continually circulating from the pump to the motor through the meter and back to the pump. A person supplied with this water would not be using the water itself but the energy which it was able to deliver to the machine. This energy could not be measured in gallons because the energy would depend upon the difference of pressure between the inlet to the water motor and the outlet. If there were a great difference, the motor would run very fast and do a great deal of work at the same time. A great amount of water would flow through the motor. A meter would then have to be constructed which would measure the amount of water flowing through the meter per second, and the difference in pressure in pounds per square inch.

Now, the measuring of electricity may be compared to this example. The amount of electricity passing through the wires, corresponding to the gallons of water per second, is called **amperes,** and the pressure of the electricity, corresponding to the water pressure in pounds per square inch, is called **volts.** For example, a 110-volt current refers to the pressure by which the current is being forced over the wire. By multiplying the amperes by the volts we obtain a unit which expresses the rate of doing work or power, called **watts.**

FIG. 265.—An instrument for measuring electrical pressure, volts.

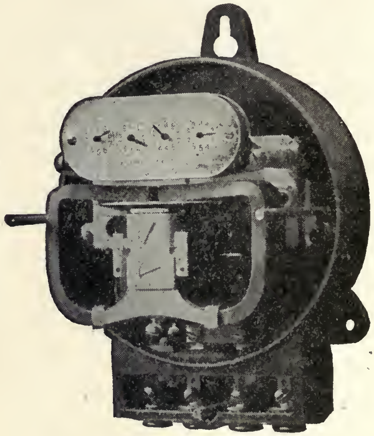


FIG. 266.—Watthour meter.

An instrument which requires a watt of any energy would consume in one hour a **watthour** of energy.

The commercial unit for the measuring of electrical energy is called a **kilowatt hour,** which means **1000 watthours.** A 25 watt lamp will use 25 watthours in an hour, or the electrical energy supplied to the lamp in forty hours would equal 1 kilowatt hour (1000 watt hours).

The Watthour Meter.—A watthour meter is essentially a small electrical motor driving a registering dial. All electricity which is used in the house must flow through this motor. If only one lamp is in use a small amount of current passes through. If two lamps are used, twice as much current passes through the meter. The increase will be in amperes, since the volts remain constant. For

example, if one light uses 1 ampere of current at 110 volts, two lights will use 2 amperes at 110 volts. The motor turns in the meter, thus registering the amount of energy delivered to the consumer.

Accuracy of Meters.—As a rule watthour meters are quite accurate. They need cleaning once in a while, as dirt and dust usually tend to make them run slowly. Occasionally a meter may be fast.

Causes for Increase in Electrical Bills.—There are a number of causes for the increase in electric bills for any month. Some of the causes are:

1. Defective wire, which may allow the current to flow when no lights or other electric instruments are in use. This can be determined by watching the small aluminum disc on the meter. If it is revolving when all lights are out, there is probably a leak.

2. An unusual number of cloudy days or much rainy weather during any month may cause an extra consumption of current.

3. Old lights which are dim do not give sufficient illumination, and require an extra light to offset the decrease in light they cause by their dimness. An old light is a very wasteful thing to use.

Carbon lights are very expensive to operate as compared with the Tungsten lamps. The latter may cost more to purchase, but the amount of current that a carbon lamp consumes during its lifetime is about three times that consumed by the Tungsten lamp for the same amount of light. One could not afford to use carbon lamps if they were given to him, since it would be cheaper in the end to buy good Tungsten lamps.

Experiments.—Measure the candle power of a Tungsten lamp and also of a carbon lamp. How many watt hours will it take to run these lamps 400 hours (the average life of the lamp)? How much does it cost per candle power? How much would it cost to run enough carbon lights to equal the candle power of the Tungsten light? What is the difference in the cost? Subtract the price of the Tungsten lamp from the difference in cost and thus determine the amount of saving.

4. Lights may sometimes be left burning for days in attics, closets, and cellars, a practice which will increase the electric bill for any month.

5. An error may be made by the company's meter reader so that

the bill rendered is too high or too low. If it is too high for one month, it will be too low the following month; consequently the consumer will not lose, if the meter is correct.

Most electric companies are interested in keeping the meters accurate, and will usually make any test upon any meter whenever asked. Applications should be made to the Electric Company, and not to the meter reader or bill collector. Since no measuring device can be absolutely accurate, a 4 per cent tolerance above and below the amount which the meter usually reads is always allowed. Meters are usually tested so that they will not be more than 1 per cent either fast or slow.

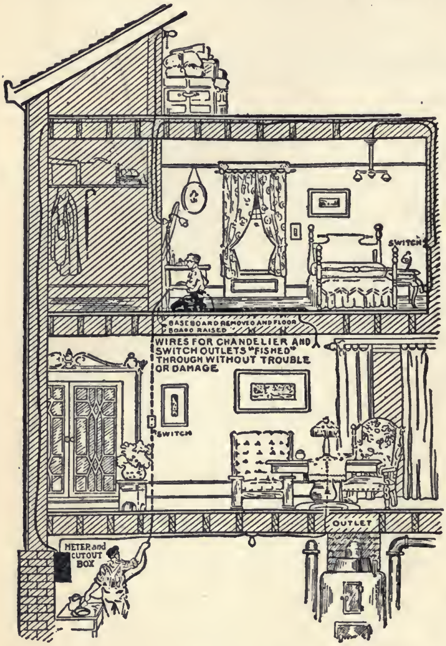


Fig. 267.—Cross-section of house, showing spaces between partitions and floors through which electric wires are easily fished (or drawn) without any disfigurement to the room interiors.

Causes of Fire.—Electric wiring of buildings must be done by competent people, since wires which are too small to carry the amount of current necessary for the consumer may become very hot, if too much current passes over the wire. This burns off the insulation, and sets fire to the building. Wires should be drawn in steel or iron pipes called **conduits.** This not only provides against danger of fire, but allows a defective wire to be pulled out and a new one substituted. Wires which are used in an extension from the lamp socket should be well constructed.

Insulation.—Electricity is conducted over some substances much more easily than over other substances; for instance, electricity runs over copper wires easily, but it does not pass through rubber.

A good conductor of electricity is some material which will carry the current. A poor conductor of electricity is something which will keep the current from being carried away. Wires are covered with rubber, cloth, paper, etc., because they are poor conductors. Glass is used on telephone wires to keep the electricity from running off into the ground, and on lightning rods to keep the electricity from running into the house. When a house is protected with lightning rods these glass insulators must be carefully replaced as soon as broken.

Questions

1. How does gas differ from electricity?
2. How does the use of electricity compare with the use of water?
3. How does a water meter compare with a wattmeter?
   Find out how much current the lights of your home consume each hour.
4. What are some of the causes of an increase in your electric bill?
5. If you were given carbon lights, would you save any money by using them in place of Tungsten lights?
6. What kind of insulation would you prefer on wires about your home?
7. What kind of wires should be used to connect vacuum cleaners and lamp lights with lamp sockets?

MAGNETS AND MOTORS

Magnets.—There are two types of magnets; permanent magnets and electro-magnets. The word magnet came from an ancient city of Asia Minor near Magnesia where a black ore of iron was found. This ore attracted pieces of iron or steel, and also nickel and cobalt. The ore is now found in various parts of the earth, and is called lodestone (leading stone), since it points to the North and South magnetic poles if suspended on a string. A piece of steel may become a permanent magnet by stroking it with this mineral. Steel retains its magnetism much longer than soft iron; hence steel is used for needles of compasses to-day in place of lodestone which was used

by the ancients. The electro-magnet is made by winding a piece of soft iron with wire, and allowing a current of electricity to run through the wire. Such magnets lose their magnetism almost as soon as the current of electricity is broken. Magnets of this type

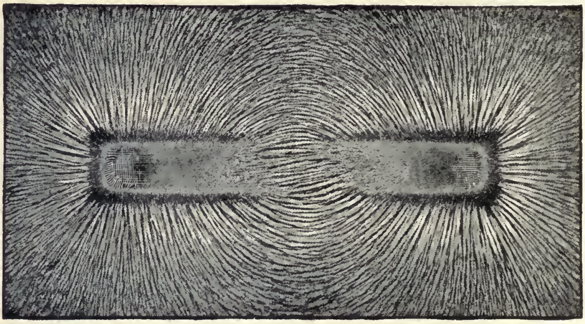


Fig. 268.—Iron filings on a paper placed over a bar magnet.

are used in electric bells, telegraph instruments, induction coils, motors and dynamos.

Experiments with Magnets.—Place a horseshoe magnet or bar magnet under a sheet of paper or glass. Shake iron filings evenly

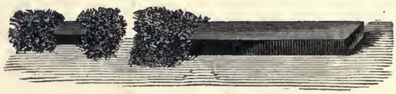


Fig. 269.—Put a bar magnet on top of some small tacks spread out on a table, and then lift it up. The tacks will be found to cling to the magnet, but in unequal numbers at different parts. The magnet has polarity; that is, the places near the ends where most tacks collect are called poles.

over the paper with a salt shaker. Observe the force of magnetism, and the direction of the magnetic lines.

Experiment with Electro-Magnet.—Wind a piece of soft iron with insulated copper wire. Attach the end of the wire to an electric battery. Bring the end of the magnet near tacks or other pieces of iron. Break the current of electricity. Observe what happens.

Law of Magnetic Attraction.—The point of the compass needle which is attracted toward the North magnetic pole is called the plus or North end, and the opposite end the minus or South end.

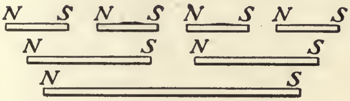


FIG. 270.—No matter how many times a magnet is broken, each part becomes a magnet with N and S poles.

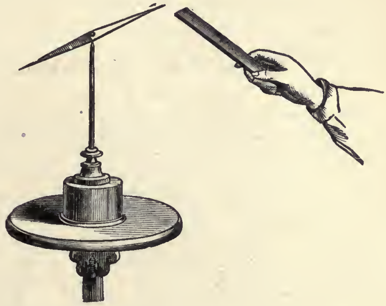


FIG. 271.—S attracts N. N repels N. What will S and S do?

Experiment.—Bring the North end of a magnetic bar near the North end of the compass needle. Bring the South end of the bar near the North end of the compass needle. Explain what happens. What does the law "Like poles of magnets repel each other, and unlike poles attract each other," mean?

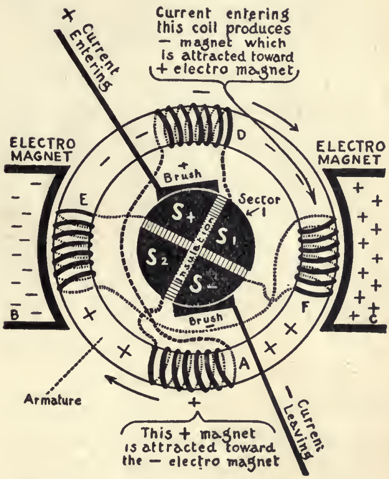


FIG. 272.—The Motor.

Motor.—The attraction and repulsion of magnets is made use of in the electric motor. The electric motor consists of a number of electro-magnets fastened rigidly to a frame, and other magnets fastened to an axis, called an armature, on which there is a drum for brushes to allow the current to enter the motor. In Fig. 272 the electro-magnet *A* (+) is attracted by the minus (−) magnet *B* and repelled by the plus (+) magnet *C*; and the magnet *D* is attracted by the magnet *C* and repelled by the

magnet *B* because the current is entering only the two coils *F* and *E*. Coils *D* and *A* have no magnetism in them, since the brushes do not touch the sectors 1 and 2, called commutators, to which these magnets are attached. As soon as magnets *A* and *D* get to the places of magnets *E* and *F*, they lose their magnetism, and the magnets *E* and *F*, taking the places of *A* and *D*, become

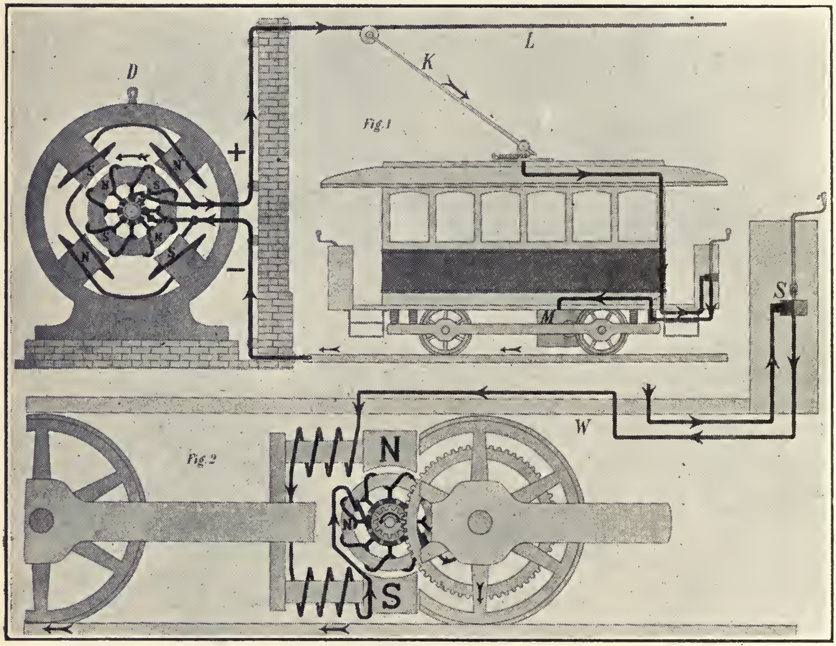


FIG. 273.—What is used for the return wire?

magnets and are likewise pulled in the same direction, causing the inner magnets on the axis to travel very rapidly.

Commercial Motors.—The commercial motors used for the running of cars, automobiles, vacuum cleaners, fans, etc., are made up of a series of magnets which are constantly attracting and repelling each other. Not only do they have magnets at *B* and *C*, but these magnets are also wound with wire to produce very strong electromagnets when the current is turned on.

Questions

1. Why not make the cores of electro-magnets of steel?

2. Why must "keepers" (bars of steel) be kept on the ends of permanent steel magnets?

3. Why does the electric car move when the motorman "turns on the current."

4. Why is it necessary to have electro-magnets in a motor?

5. How could a motor be made to run backward (reverse)?

GENERATION OF ELECTRICITY

Static Electricity.—Rub a hard rubber rod briskly with a piece of catskin. Hold it near two pith balls suspended by a silk thread. Try the rod on a bit of paper, cork, etc. Rub a rod of glass with a piece of silk or flannel. Bring this near the pith balls.

This experiment shows that there are two kinds of electricity generated. That generated by the **glass rod** rubbed with silk is called **positive**; that generated by the **rubber rod** rubbed with flannel is called **negative.**

If a body charged with negative electricity is brought near a body charged with plus electricity, the two bodies are attracted toward each other, but two bodies charged with the same kind of electricity are repelled from each other.

Rub your fountain pen on your coat and hold it near one pith ball which you have charged with plus electricity. What kind of electricity is the fountain pen charged with? Test a number of different materials rubbed with fur, catskin or flannel.

Potential.—If you hold a charged rod rubbed with fur near the finger you will feel a little prick and hear a sharp snap which show that a spark of electricity passes from the rod to your finger. Also a charge passes from your finger to the rod, neutralizing the plus and minus charges. This exchange of electricity which takes place between two bodies is caused by the difference in potential or pressure of the electricity. We have already called it volts. This electricity contains no amperes of current; it is simply very high voltage. A spark 1 inch long has a voltage of about 75,000 volts.

Lightning.—Lightning is caused much in the same way. A great deal of electricity is carried up from the earth while water is evaporating. Also a great deal of electricity is generated by the friction of clouds and wind. When clouds are very high above the earth, flashes of electricity will pass between them, but if a cloud is near the earth, the flash of electricity will pass between the cloud and some object on the earth. We commonly say the lightning strikes

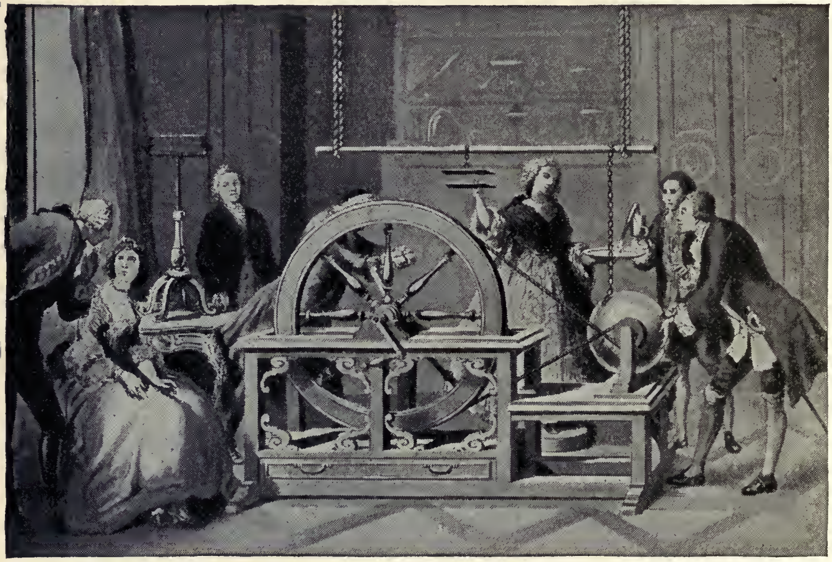


Fig. 274.—Volta entertaining his friends by generating static electricity.

the object. Lightning rods have been placed on buildings in order to protect them from this great spark of electricity. The rod extends slightly above the highest point of the building, and runs down the side of the building into the moist earth. Buildings that are well protected by lightning rods are very seldom struck by lightning, since the current of electricity passes down the rods into the ground. Very often, too, no spark is seen at all. Such rods are very dangerous if they are not well insulated from the buildings.

Thunderstorms. Thunderstorms usually occur late in the afternoon or early evening of a hot sultry day. They are classed as traveling storms. Before the thunderstorm breaks, heavy masses of clouds are seen slowly rising and collecting near the horizon. The air which is very warm begins to be slightly cooler. Small detached clouds, forming in front of the large clouds, rapidly increase in size and unite with the advancing storm cloud. Ragged squall clouds travel underneath the dark heavy clouds. Some of the storms travel from twenty-five to fifty miles, carrying clouds of dust. At first large raindrops form

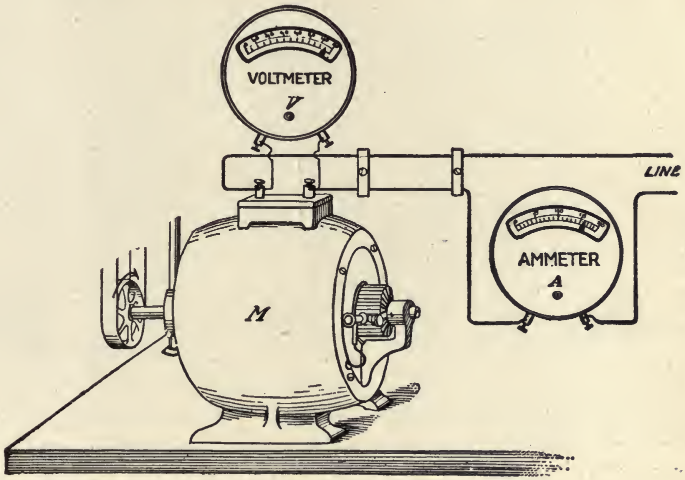


FIG. 275.—Voltmeter measures the pressure. Ammeter measures the amount of current. Why is it necessary to have all the current go through *A*?

which soon become smaller in size and greater in number until there is a heavy downpour. Occasionally hail attends thunderstorms.

The most dangerous place in a thunderstorm is under a tree, as lightning usually strikes the highest points. Cattle are frequently killed in the pasture by the lightning striking the wire fence. Farmers should ground wire fences every few feet so as to allow the lightning to travel into the ground.

The Dynamo.—Attach a coil of wire to a galvanometer. Move a bar magnet slowly up and down in the coil. The end of the needle

will be seen to move, and the direction it takes will depend upon the direction the magnet is moving in the coil. This shows us how electricity is generated. We have already learned that radiating from the magnet are lines of magnetic force. As the magnet moves in the coil these lines of force are cut bv the wires, and the current

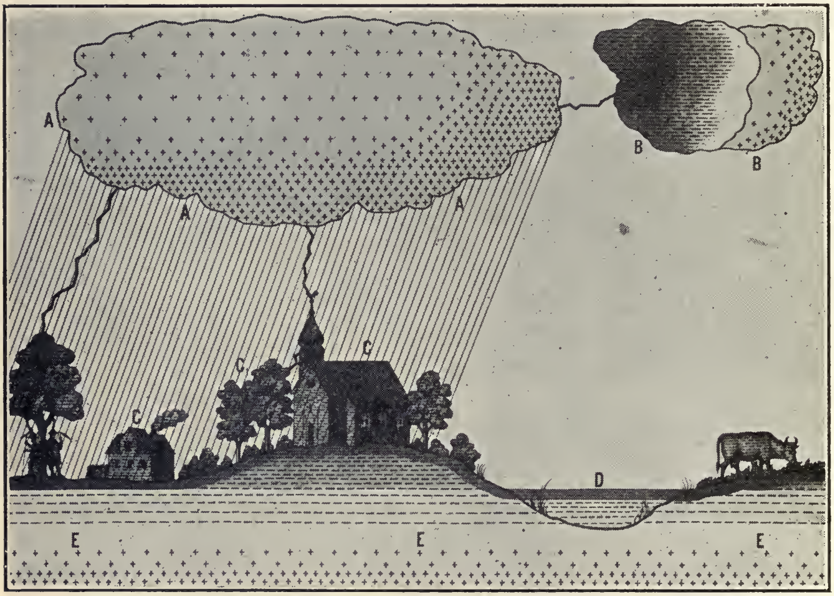


Fig. 276.—Thunder Storm. *E*, earth charged near the surface by minus electricity. Why? *A*, cloud charged with plus electricity, *C*, church, trees and house, charged with minus electricity. The man, the cow, the water, and all objects on the earth are charged with minus electricity during a thunder storm. Why does the lightning "strike" the church or tree rather than the cow or ground? Why is the interior of the earth charged with plus electricity during a storm? Why is the left side of *B* − and the right side +?

of electricity is induced in the wire. The commercial dynamo is built on the same principle. Coils of wire on the armature are rotated in front of powerful magnets. In order to make the magnets more powerful all the current generated by the dynamo is allowed to pass through the wires around the magnet. This is called a series-

wound dynamo. If only a part of the current goes through the wires on the magnets, and the other part goes directly to the supply wires, this dynamo is called the parallel-wound dynamo. If the two systems are combined in one dynamo, the dynamo is said to be a compound one. This is the type of dynamo usually found in power-houses for generating current.

AC Currents and DC Currents.—The galvanometer will show that the current changes its direction in the wires when the bar

Fig. 276*A*

magnet changes its direction; for example, the current flows in one direction when the magnet is pushed down through the coil, and in the other direction when the magnet is pulled out from the coil. Currents which are constantly changing their directions are called alternating currents (**AC**), when the coil passes down in front of a magnet, causing the current to flow in one direction. When the coil comes up on the other side of the dynamo, by a magnet, the current is caused to flow in the opposite direction. Sometimes it is necessary to have direct currents (**DC**) in place of alternating currents (**AC**); trolley cars, for example, use direct current. The

trolley-wire supplies current directly from the dynamo, and the track acts as the return wire to the dynamo.

Alternating (*AC*) currents and direct (*DC*) currents are generated on the same dynamo. The method by which the current is obtained is through the arrangement of the **commutator.** Fig. 277 shows the method by which alternating current is obtained from a dynamo. As the wire 1 passes by magnet *S*, current is generated in the direction of the arrow, which is carried by the wire to the brush on the armature at *A*. As wire 1 moves from the bottom of the magnet *N* toward the top, current is generated in the direction

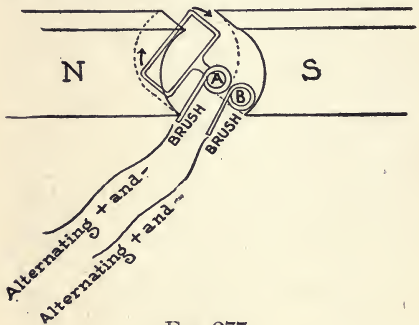


FIG. 277.

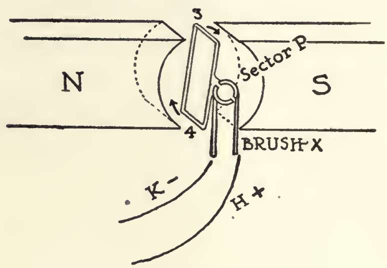


FIG. 278.

shown by the arrow on wire 2, which is directly in the opposite direction from that in which the current was going when the wire was passing *S*, causing the brush *A* first to send off current and then to have current return into the dynamo from the supply wire *X*. In the meantime, wire 2 generates the current in the direction of the arrow while passing magnet *N*, and in the opposite direction when the armature has turned so that wire 2 is passing magnet *S*, alternately receiving and sending a current over the brush at *B*. Fig. 278 shows the method by which direct current is obtained from a dynamo. As wire 3 passes by the magnet *S*, current is generated in the wire in the direction of the arrow. The current is taken off at the commutator by the brush *X*, which touches the sector *P*. It will be seen that the commutator is divided into two sectors or parts, *P* and *T*. Current will come off the wire *H*. As wire 4 passes magnet *N*, current will be generated in the wire in the direction of the

arrow; hence wire K will act as the return wire. When 4 reaches the position of 3 and starts to move by magnet S, current will be generated in the direction of the arrow at 3, causing the current to leave by sector T which is now in the position of P, causing the current to flow out over the brush X.

The Cycle.—A cycle in a dynamo occurs when a plus magnet or wire on the armature passes from a plus magnet by a minus magnet to a plus magnet again. For example, if there are two magnets such as in Fig. 277, the passing of the wire from the north magnet by the south magnet and back again to the north magnet represents one cycle, that is, the wire turns around once. If the dynamo had four magnets (two north and two south poles), the wire would pass through two cycles in turning around once. How many cycles would the dynamo have if there were sixteen plus and sixteen minus poles on the dynamo? How many cycles per second would the dynamo have if the wire turned around ten times in one second?

The Cycle for Lighting.—Alternating currents would naturally cause lights to flicker, since the current first enters the light one way and then completely reverses. A sixteen candle power (c.p.) of 110 volts begins to show flickering at about 30 cycles per second. At 25 cycles the flickering is noticeable, and at 20 cycles it is intolerable. This is true of arc lamps. It is often the cause of the flickering of moving pictures which is so annoying to an audience. This is corrected to some extent by enclosing the arc and keeping the arc as short as possible. Difference in the hardness of the carbons also assists.

Questions

1. Why does the hair sometimes snap when being combed with a rubber comb?
2. When would lightning strike a building?
3. Why are sparks seen if a cat's fur is rubbed in a dark room?
4. What kind of substances conduct electricity well?
5. Why can not static electricity be generated from an iron rod, since it can be generated from a glass or rubber rod?
6. Who invented the lightning rod?
7. Why are lightning rods pointed?

8. Why should the ends of lightning rods be buried deep in the ground?

9. Why are people killed if they touch a " live " wire?

10. Why may a man who is fixing a trolley wire touch the wire if he is wearing rubber shoes?

11. Since the trolley track is the return wire to the dynamo, why is it possible to stand on the track without receiving any injury?

12. What is the third rail?

OTHER USES FOR ELECTRICITY

Ohms.—When electricity passes over a wire, the wire becomes heated. This is due to the resistance the wire offers to the current.

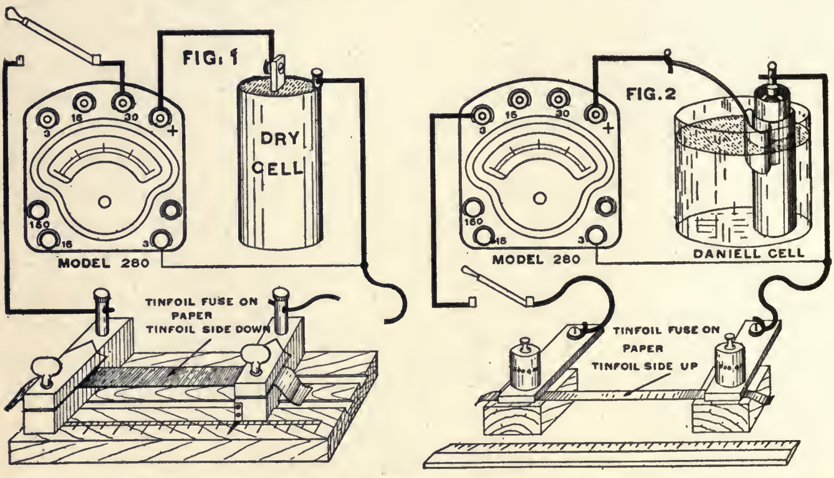


FIG. 279.—Make several fuses as directed. Determine the amount of current a long, a short fuse, a wide and a narrow fuse will hold. How do you think 20, 30, 50, ampere fuses are made?

If a large amount of current is driven through a small wire, the wire becomes very hot because it offers a great deal of resistance.

The amount of resistance is measured by **ohms.** (What is an ohm?)

Wires for carrying a great deal of current must be very large to prevent them from becoming hot. The right sized wire must

be placed in a house, or too much current running over the wire will cause the wire to set fire to the house.

Fuses.—Sometimes through short circuits (What are short circuits?) a great deal more current goes over the wire than should. If this excess of current continues to flow, the result will be disastrous. For this reason, fuses are used. These are made of metal which melts at a low temperature. When the current becomes too "strong" the heat melts them, " blows out " and breaks the current of electricity, and prevents damage.

We can find out the resistance offered by lights, flatirons, electric stoves, etc., by the formula

$$\textbf{Amperes}\text{ (current)} = \frac{\textbf{Volts}\text{ (pressure)}}{\textbf{Ohms}\text{ (resistance)}}.$$

If the plate on the flatiron reads 5 amperes you must find out what the voltage of your current is. If it is 110 volts you can easily find the amount of resistance of the flatiron.

$$5 \text{ amperes} = \frac{110 \text{ volts}}{\text{ohm}},$$

or 22 ohms of resistance. If the amount of current is given in watts, we must divide the number of watts by the voltage to get the amperes, since watts equals volts × amperes.

Electric Heaters.—Electric stoves, heaters in cars, electric bed warmers, electric flatirons, etc., all work on the principle of getting small wires very hot.

Electric Incandescent Lamp.—The carbon or Tungsten lamp contains small wires which offer great resistance to electric currents. They become white hot, giving us light for our homes.

Amount of Resistance Required.—We have already mentioned that the amount of current which can get over a wire depends upon the amount of resistance, **ohms of resistance,** the wire offers to the current. It also depends upon the pressure **volts** with which the current is being driven over the wire. The harder the current is " pushed " or driven over the wire the hotter the wire becomes.

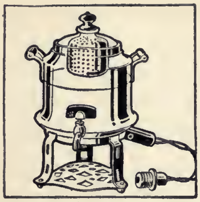


FIG. 280.—Electric samovar.

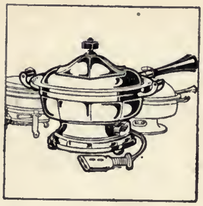


FIG. 281.—Electric chafing dish.

FIG. 282.—A handy electric stove.

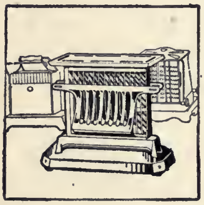


FIG. 283.—Electric toaster.

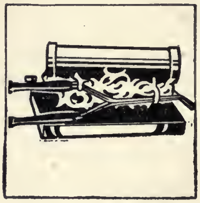


FIG. 284.—Electric heater for curling iron.

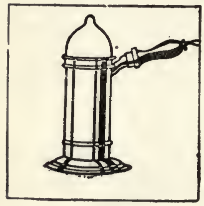


FIG. 285.—Electric milk warmer.

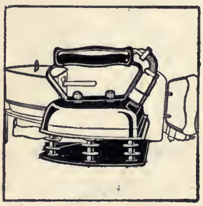


FIG. 286.—Electric iron.

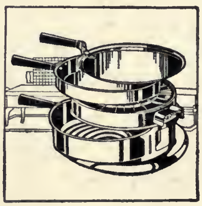


FIG. 287.—Electric grill.

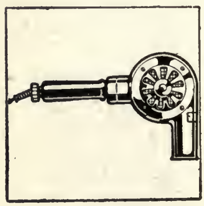


FIG. 288.—Hair drier.

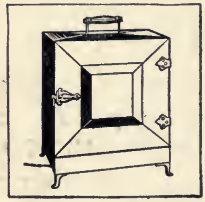


FIG. 289.—Electric plate warmer.

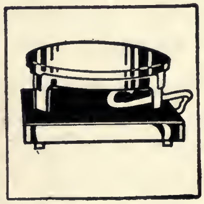


FIG. 290.—Electric hot plate.

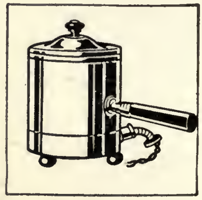


FIG. 291.—Hot-water cup.

FIG. 292.—An electric curling iron and drying comb.

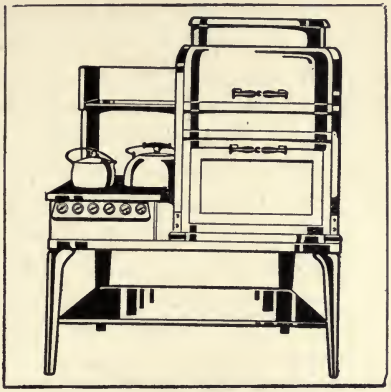


FIG. 293.—Electric range.

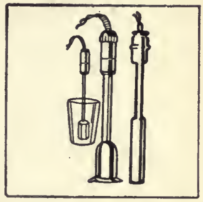


FIG. 294.—Electric heater for shaving.

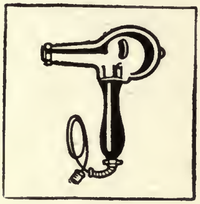


FIG. 295.—Electric vibrator.

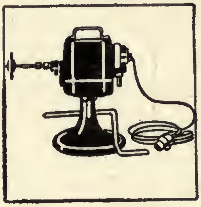


FIG. 296.—Electric motor for polishing.

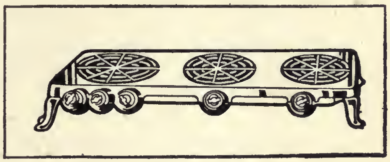


FIG. 297.—Electric disc stove.

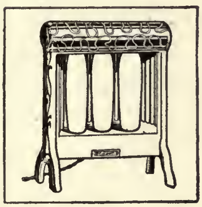


FIG. 298.—Electric glow radiator.

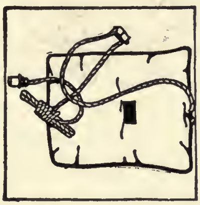


FIG. 299.—Electric bed warmer or pad.

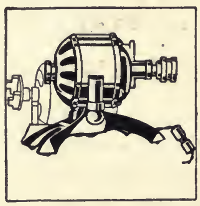


FIG. 300.—Handy electric motor for sewing machine.

FIG. 301.—Electric coffee percolator.

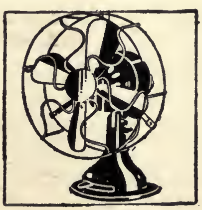


FIG. 302.—Electric fan.

FIG. 303.—Hot pad.

Electroplating.—When an electric current is sent through a dilute copper sulphate solution in which there is a piece of iron, the iron will become covered with copper if the current enters the solution over a piece of copper and leaves the solution over the iron. Silver, gold, and nickel plating are done this way. When the article is to be plated with silver, the material is placed in a silver solution. Then the current enters the liquid over a silver bar, leaving the solution over the spoon or other article to be plated.

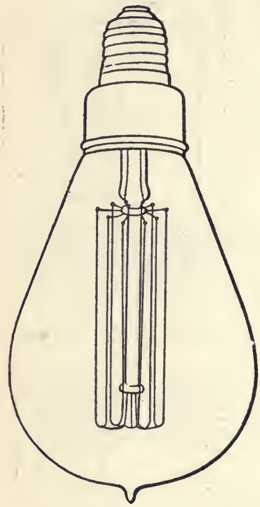


Fig. 304.—Why do the wires become very hot? Why do they glow?

The solution is called an **electrolyte.** The wires over which the current passes in and out of the solution are called **electrodes.** The wire by which the current enters is called the **anode** and the one by which the current leaves is called the **cathode.**

Electrolytic Method of Cleaning Silver.—The tarnishing of metals is generally due to the formation of oxides on the metals through the chemical action of oxygen and the water vapor in the air. Unlike other metals silver and gold are not tarnished by oxygen or moisture of the air. Silver, however, readily forms black silver sulphides on coming in contact with the sulphur compounds which are produced from the burning of coal and illuminating gas. Some foods contain sulphur compounds; eggs, especially, being an example.

The usual method of cleaning silver with silver polishes is to rub the silver sulphide from the silver with some form of very fine polishing powder or paste. This method, however, constantly removes the silver, requiring a new plate after a period of time. The best way of cleaning silver is through the **electrolytic method.**

Fill an enamel or agateware dish partly full of a clean solution of one teaspoonful either of washing or baking soda and one teaspoonful of common table salt to each quart of water, and place directly on the burner to boil. Drop a sheet of aluminum or clean zinc into the dish and place the tarnished silver in with the metal. See that the silver is entirely covered with the cleaning solution,

and that the solution remains at boiling temperature. As soon as the tarnish has been removed, remove the silver, rinse in clean water and wipe with a soft cloth.

Aluminum corrodes in a cleaning solution of this type so that the aluminum ware should not be used unless kept for this particular purpose. Zinc may be used, but it becomes corroded and inactive in a short time unless treated with a strong muriatic acid. It is, however, less satisfactory than aluminum.

Questions

1. Why is it necessary for lights to have high resistance?
2. Why do you have fuses in your home?
3. Why is the telephone wire fused?
4. Find the resistance in ohms of the lights about your home, of the vacuum cleaner, or electric flatiron.
5. If your home is wired for electricity, find out what size of wire was used.
6. Why are fuses enclosed in a barrel or fireproof casing?
7. Examine a cartridge fuse.
8. Cut one open which has not been "burned out."
9. Cut one open which has been "burned out."
10. Look in a screw-enclosed fuse.
11. What do we mean when we say 15 ampere fuse or 60 ampere fuse?
12. What would be the difference in the comparative size of the wire used for each?
13. Why is it not safe to put a 30 ampere fuse on a wire which is supposed to carry only 15 amperes?
14. Why is bell wire unsafe to use on electrical appliances which are attached to the supply current?
15. Find the resistance of some of your lights at home.
16. What kind of light seems to have the greatest number of ohms of resistance?
17. What is the difference between the resistance of the high candle power lights and the low candle power lights?

18. What is the difference between the resistance offered by Tungsten lights and carbon lights?

19. Why does great resistance reduce the cost of operation?

20. Why is the electrolytic method of cleaning silver better than the polishing method?

USES OF MAGNETS AND CELLS

Electric Bell.

Examine the electric bell.

What are the magnets *H* and *I* called?

G N is a piece of soft iron.

Why is *G N* pulled to the magnets *H* and *I* when a current of

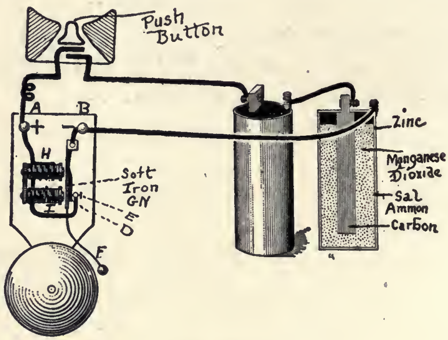


FIG. 305.

electricity enters the wire around the magnets? The current enters the bell at *A* and leaves at *B*. Why does the hammer *F* hit the bell when the current is turned on? What happens at *D* and *E* when *G N* is pulled toward the magnet? When the current is broken, what happens to the magnets *H* and *I*?

As soon as *I* and *H* lose their magnetism, *G N* springs back, causing *D* and *E* to meet again.

Why do *G* and *H* become magnets again?

How quickly do you think *G* and *H* become magnets, and lose their magnetism?

What is the push button for?

Telegraph Instrument.—Telegraph instruments consist of electro-magnets which cause a little bar of metal to be drawn to the magnets. Examine a telegraph instrument. What causes the "tick"?

The key acts as the push button, turning on the current through the magnet. Many of these instruments are connected in series in different towns, and messages are sent by means of dots and dashes.

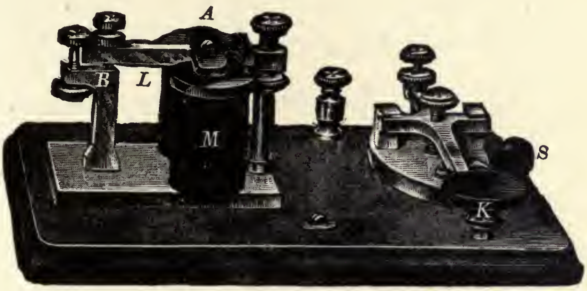


FIG. 306.—Telegraph instrument. Why is A a soft piece of iron? Why is M an electro-magnet?

WIRELESS CONTINENTAL TELEGRAPH ALPHABET

·	E	—	T	······	Period
··	I	——	M	·—·—·—	Comma
···	S	———	O	··——··	Question
····	H	————	CH	——··——	Exclamation
				—···—	Break
·—	A	—·	N	—····—	Hyphen
··—	U	—··	D	···———···	Distress
···—	V	—···	B	···—·	Understand
·—·	R	·——·	P		
·——	W	——·	G	—·—·—	Call
·———	J			···—·—	Finish
·—··	L	··—·	F	·—···	Wait
				Abbreviations	
—·—	K	—··—	X	QRT	Stop Sending
—·—·	C	——··	Z	QST	Attention
——·—	Q	—·——	Y	QRM	Interference
·————	1	————·	9	QRN	Static
··———	2	———··	8	QRX	Stand by
···——	3	——···	7	QRA	What Station is that?
····—	4	—····	6		
·····	5	—————	0		
·—·	Dot	—··—·	Fraction Bar		

MORSE CODE

International Morse Alphabet

A	·—	N	—·
B	—···	O	———
C	—·—·	P	·——·
D	—··	Q	——·—
E	·	R	·—·
F	··—·	S	···
G	——·	T	—
H	····	U	··—
I	··	V	···—
J	·———	W	·——
K	—·—	X	—··—
L	·—··	Y	—·——
M	——	Z	——··

Numerals

1	·————	6	—····
2	··———	7	——···
3	···——	8	———··
4	····—	9	————·
5	·····	0	—————

Punctuation

Period	······	Bar Indicating Fraction	—··—·
Comma	·—·—·—	Underline (before and after the Word or Words it is wished to Underline)	··——·—
Interrogation	··——··	Double Dash (between Preamble and Address. Between Address and Body of Message, etc.)	—···—
Hyphen or Dash	—····—	Cross	·—·—·
Parentheses (before and after Words)	—·——·—		
Quotation Mark (Beginning and Ending)	·—··—·		
Exclamation	——··——		
Apostrophe	·————·		
Semicolon	—·—·—·		
Colon	———···		

Cells.—An electric cell may be made by so placing pieces of zinc and copper, called an **electrode,** in dilute sulphuric acid that the two pieces of metal are separated. If a wire is used to connect them outside the acid an electric current will flow from the copper (+) to the zinc (−) on the wire. From what and to what does the current flow inside the battery?

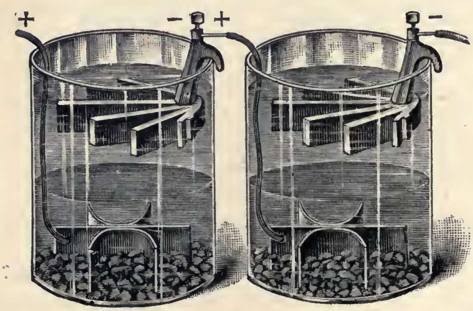


Fig. 307.—Two wet batteries attached in series.

Wet Cells.—The most common wet cell used is

one made from sal-ammoniac (ammonium chloride) dissolved in water. Zinc and carbon are used for electrodes. The current flows from the carbon to the zinc on the wire outside the battery.

Dry Cells.—The " dry cell " is made up of a zinc jar in which is packed damp sal-ammoniac surrounded by manganese dioxide. Pitch is placed over the top of the materials to prevent the water from evaporating. A piece of carbon is placed in the center of the cell from which the current flows.

Open an old dry cell and examine the structure.

Parallel and Series.—Batteries, lights and many electrical instruments are wired in parallel or series according to the requirements.

Batteries are wired in parallel by running wire from the zinc to the zinc, and from the carbon to the carbon, thence to the instrument.

The result of parallel connection in batteries is to produce a large number of amperes and the voltage equal to one cell. Electroplating work requires such conditions.

Whenever we wire batteries to door bells we need as much voltage as possible to drive the current over the wires, for they may be 100 feet or more in length.

The batteries are wired in series from carbon to zinc.

Electric lights for our homes are wired in parallels since the lights must be turned on independently of each other.

Where two or more electric bells are operated from the same push button they should be wired in parallel.

Storage Cell.—The storage cell is used in automobiles, in homes and in schools for many purposes requiring the use of electricity. These cells must be charged. The electricity does not really go into the cell and stay there but stores up its energy in the cell. This energy once stored up is a source of current in the opposite direction from which the current passed into it.

Project:—Find out how storage cells are made; the different places where they are used; how they are charged; when we know they are fully charged, and what the cell contains.

A Battery.—A battery is a number of cells united in series or parallel. Sometimes a single cell is called a battery. This, of course, is an incorrect use of the word.

Questions

1. Why is the voltage marked on the lights in your home?
2. What would be the effect of placing a lamp marked 110 volts on a current which had a pressure of 220 volts?
3. Why are flatirons, vacuum cleaners, etc., marked with both amperes and volts?
4. What causes the telegraph instrument to tick when one presses the key?
5. Why are " dry cells " called dry cells?
6. Why are lights in a home wired in parallels?
7. What would be the effect if the lights were wired in series and one light went out?

CHAPTER XII

THE RELATION OF SOUND AND MUSIC TO US

SOUND

Sound Waves.—We have learned that light comes to us through a series of waves which affect the optic nerve. Waves which are produced in the atmosphere we call sound waves. They affect the auditory nerve of the ear. As sound is the result produced by the waves striking the ear drum and sending a sensation over the auditory nerve to the brain, sound is really in the head. The waves themselves do not produce any sound. There are as many sounds in a place as there are ears to receive the sound. If one should strike a blow and extend his finger in front of him, there would be no sound at the end of his finger. Sound waves, however, might beat against the finger and also pass on until they reach some body which is capable of receiving the sound waves on some tissue which will produce a sensation of sound.

Sound waves move out in a straight line from their source, not like the waves of the ocean but in a backward and forward motion, on the same principle as when one billiard ball strikes another, forcing ahead the one that is hit. If the second ball hits a third, the third is pushed forward, and so on.

Sources of Sound Waves.—Sound waves are produced from vibrating bodies. Something must move in order to set the air in motion. There are many sound waves which do not produce sounds to the human ear. Some bodies vibrate so rapidly that they send off a series of sound waves which hit the ear drum with a greater rapidity than the auditory nerve can receive and form into sensations of sound. A body vibrating sixteen times per second produces the lowest sound we are able to hear.

32 vibrations per second produces the lowest musical sound.
128 vibrations per second produces man's conversational voice.
512 vibrations per second produces woman's conversational voice.
2,000 vibrations per second produces high soprano.
4,000 vibrations per second produces highest musical tones.
40,000 vibrations per second produces highest audible sound.

The Ear.—Sound waves enter the ear, which has the right shape to collect a large number of vibrations. Waves strike against the

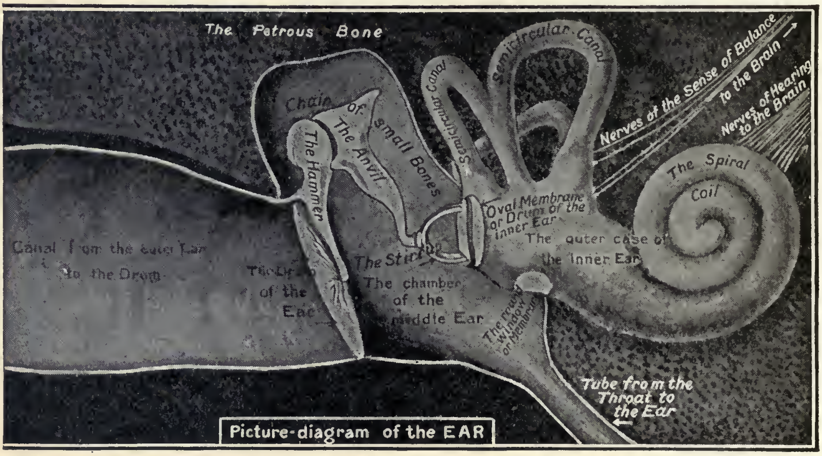


FIG. 307*a*.—This diagram shows the inside of the ear, from the entrance to the end of the nerve that passes to the brain. The drum is stretched across the end of the canal, and on the other side is the chamber of the middle ear, filled with air that enters from the throat. In this chamber are three small bones, the hammer, the anvil, and the stirrup, the last being fixed to the drum of the inner ear which is shaped like the coils of a snail's shell.

thin membrane called the **tympanic membrane.** To this membrane are attached three little bones, **the hammer, the anvil,** and **the stirrup,** which assist in transmitting the vibrations produced by the sound waves through the middle ear to the **cochlea.** The cochlea is filled with a liquid in which are stretched about three thousand filaments of the auditory nerve. These little filaments vibrate sympathetically

with the sound waves on the outside to transmit a sensation to the auditory nerve, and thence to the brain.

If the number of vibrations of the sound waves is less than 16 per second, these little filaments are not affected and no sound is heard. If the sound vibrations are more than 40,000 per second, the auditory nerve is unaffected.

It is believed by some that many insects produce sound waves with too high a number of vibrations or too low a number of vibrations to be transmitted into sound and heard by human beings.

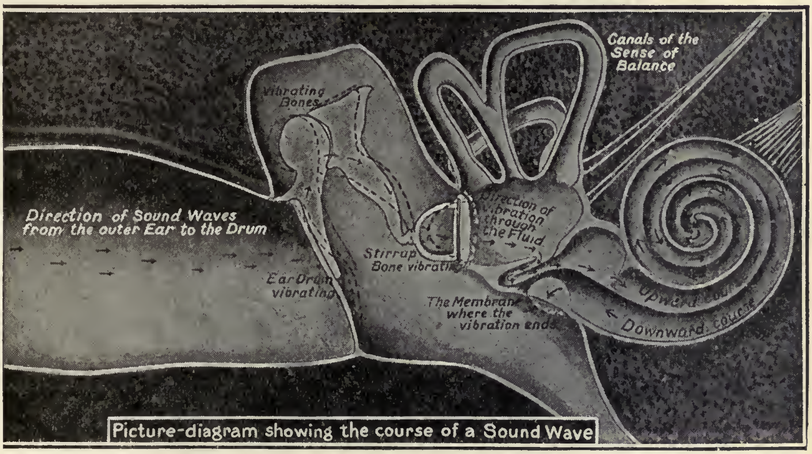


FIG. 307*b*.—Here we see a sound-wave striking the drum of the ear. The vibration moves the handle of the hammer which pulls the anvil and pushes the stirrup, as shown by dotted lines, against the drum of the inner ear. Tiny waves of the fluid inside this inner ear pass through a membrane which lines the shell, and, traveling round the coils in the direction of the arrows, communicate the sensation to the nerve, and then return by another canal. *Courtesy of Child Book of Knowledge.*

Echo.—When sound waves are stopped by any object and sent back again without being altered in shape, an **echo** is produced. If the sound waves are broken and come back very irregular they do not produce an echo.

The ancients believed that the echo was produced by a nymph, Echo, a daughter of Air and Earth. The story goes that Echo at

one time could talk like other people. Jupiter employed her to talk to his wife Juno and keep her so busy she would be unable to watch him. When Juno discovered this she punished Echo

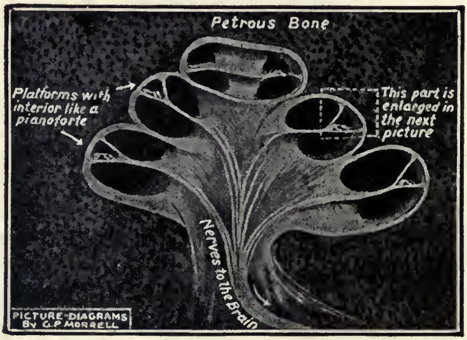


Fig. 307*c*.—In this picture the spiral coil is cut through from top to bottom. The little galleries are filled with fluid, and contain very marvelous organs. The part in the dotted square is shown in the next picture enlarged.

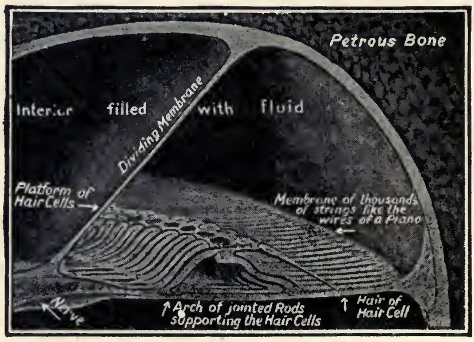


Fig. 307*d*.—Over 3000 little hammers, jointed like those of a piano, support thousands of hair-cells that rest on a membrane. More than 10,000 strings are stretched across like piano wires, and these convey the wave sensation to the nerve.

by condemning her to repeat the last few syllables of any word or sentence repeated in her presence.

If you stand in front of a tall cliff or hill and shout or sing, the sound or sounds will be repeated. The sound waves strike

the cliff and are sent back, producing the same sound you made. Water is a good reflector of sound. People in balloons can easily hear sound reflected from water.

Clouds will reflect sound. This is shown by firing a cannon. If the sky is clear a large gun produces a sharp report, but if there are clouds in the sky the report of the gun will be heard as an echo similar to thunder "rolling." In fact, the rolling sound of thunder is due to the sound waves rebounding from the clouds.

Whispering galleries are examples of sound waves rebounding from some point where they have concentrated, usually in a concave surface. Many of the rotundas of the capitol buildings in the United States are examples of whispering galleries, but one must stand in the place where the sound waves are reflected to a point or focus.

Sound Waves in a Room.—People often experience difficulty in hearing a speaker in some auditoriums. Sound waves travel in straight lines, unless stopped by draperies, screens, etc. Ventilating flues, hot air registers, steam radiators and air currents interfere with sound waves. A speaker who is located some little distance from the listeners, with a hot-air floor register in front of him, will have difficulty in being heard, since the sound waves are interfered with by the hot air traveling upward toward the ceiling. Some of the sound waves will be reflected back, others upward, and a small number will reach the listeners.

Hot air rising from footlights in front of a speaker will interfere with sound waves. Frequently singers prolonging a note seem to be producing an uneven tone because of the unevenness of the sound waves passing through the heated currents of air which rise from the floor between the singer and the listener. It seems necessary, then, in an auditorium to have the air evenly heated. In some halls wires have been strung to improve the resonance of the room. This, however, appears to be practically useless.

Sound waves die on soft or dead surfaces such as carpets, curtains and drapery. Velvet is the best material for exhausting sound waves. Metal mirrors and polished plate glass reflect sound waves. The best way to improve an auditorium in which voices are not well heard is so to construct walls and ceilings that the sound waves

will travel in parallel lines, returning toward the source; moreover, all walls or ceilings which cause conflicting sound waves should be constructed of dead or non-reflecting surfaces, and the resonance-box and sound reflectors should be so placed in an auditorium as to balance evenly the quality and volume of the sound. An oval shaped room seems to be the best for producing absolutely perfect results. The stage should be placed at the smaller end of the hall. Rooms which have arched ceilings are not of the best type

FIG. 307e.—The diagrams show the shape of room best adapted for reducing sound disturbances. The white dots denote the places where there is a great deal of sound disturbance, which makes it difficult for people sitting in that part of the room to hear. The per cent refers to the loss of effective hearing qualities. *X* denotes the position of the speaker. In what class does your auditorium belong? Your class room?

The illustration shows some floor plans which produce varying results, from perfect hearing to total loss of hearing qualities.

The best method of supplying heated air to an auditorium is by allowing the air to enter at a great many places on the floor of the room. A number of openings is usually provided under each row of seats so that there is a gentle and equal distribution of warm air from the hot-air supply duct.

Compare the auditorium of your school room with these diagrams.

How does it fulfill the requirements for producing the best results?

How is the room heated?

Do the hot-air currents interfere with the sound waves?

Speed of Sound.—We are all familiar with the fact that we do not hear thunder as soon as we see a flash of lightning. This is because it takes time for sound to travel. Sound travels in air at 32° F. (0° C.) 1088 feet per second, and the speed increases two feet for every degree of rise in temperature Centigrade, or a little over one foot for each degree Fahrenheit.

Sound is produced by some vibrating body which causes the air to vibrate. Sound is transmitted through a series of **condensations** and **rarefactions.** The place where the rarefaction is greatest is called a **node.** The condensation gradually grows less and less until the waves die out.

Sound waves producing two unlike tones cause **beats** or places where one wave annihilates another, resulting in silence. This produces a wavy or throbbing sensation. The ding-dong of a bell and the tremulo are good examples.

The beat is caused by the meeting of the waves, first at condensation. Since one wave is longer than the other they gradually come to a place where condensation of one wave and rarefaction of the other take place at the same time, thus producing a momentary silence.

Noise, Sound and Tone.—Any instrument which will cause the air to vibrate will produce noise, sound or tone. Noise is the result of **irregular vibrations** of the air. Sound is the result of **regular vibrations** of the air.

Experiment.—Construct a disc with a series of holes as shown in the illustration 308*a*.

Arrange the holes at equal distances apart with the inside row containing 24 holes, the next 27, 30, 32, 37, 40, 45, and 48. The last row of holes should be made at uneven distances apart. Attach the disc to a rotating motor or other rotating device and blow through each set of holes in succession with a piece of glass tubing. The outer row of holes will produce uneven vibrations, causing **noise.** The inner rows of holes will produce even vibrations, resulting in sound and also **tone.** Tone is produced in the same way as sound, but has

a certain number of air vibrations per second. For example, the sound which has 256 vibrations per second, or 258.6 vibrations (musical scale), produces the tone C.

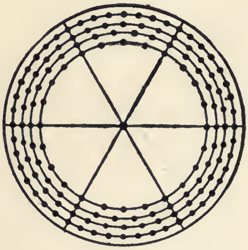


Fig. 308a.

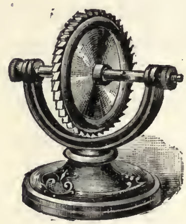


Fig. 308b.—If a piece of paper is held on the teeth of the wheel the pitch will rise as the speed increases. Why?

Questions

1. If a book fell off the table and there were no one around to hear it, why would there be no noise?

2. What causes the " snap " of a whip?

3. Why are you able to make a noise by clapping your hands?

4. Why does not waving the arms produce a noise?

5. Which talks faster, man or woman? Prove your answer.

6. Why do soldiers on the march " break step " while marching across a bridge?

7. Why is it necessary to place the sign " Walk your horses across this bridge " over the entrance to some bridges?

8. How far away would a flash of lightning be if we heard the thunder 15 seconds after we saw the flash of lightning?

9. If it were possible to hear and see an explosion on the moon, how long after the explosion would we see it. and how long afterwards would we hear it?

10. If the people on Mars could see what we are doing, how long after you did a thing would they see it? If they could hear, how long after you said a thing would they hear it?

11. Why would there be no sound from a bell in a vacuum?

12. Why do windows of a house break when a terrific explosion occurs?

13. Why does a shell or bullet whistle?

14. Why does the wind whistle?

15. Why do telegraph wires hum?

16. How do crickets produce a shrill noise?

17. Why does a person hear better if he places the small end of a megaphone to his ear?

MUSIC, AND SOUND INSTRUMENTS

Resonance.—Resonance is caused by sound waves which, in entering a cavity, such as a bottle, cause the air in the cavity so to vibrate that it reënforces these sound waves.

Experiment. On Simple Resonance.

Blow a whistle across the mouth of a large bottle, gradually raising the pitch until the tone is struck which will cause the bottle to produce sympathetic vibrations, thus reenforcing the sound waves of the whistle.

Sometimes a fly or a bee placed in a bottle of the right size gives a good example of resonance.

Hold a tuning fork over a tall cylindrical jar, slowly adding water until the sound wave given off by the fork is reenforced. A high degree of resonance is obtained.

Another interesting way to show resonance is to place over a candle or gas jet a long tube about 1 inch in diameter which just fits inside of another tube. Move the outer tube up and down over the inner tube until the proper length is obtained to produce a loud shriek.

Draw a piece of glass tubing into a fine jet and attach it to the gas fixture with a piece of rubber tubing. Hold a wire screen about 4 inches above the jet and light the gas above the screen. Place over the flame a bottle, and move the screen up and down until a loud noise is obtained in the bottle.

Sympathetic Resonance.—If a slide trombone is sounded in front of a pipe organ, a pipe which will produce the same type of tone will respond sympathetically. If the trombone is sounded from a low pitch to a high pitch the different pipes will respond, each to its own tone, and pipes which can not produce the vibrations of the tone will remain silent. This is also true of a piano. If a person sings in front of a piano, the string which has the same musical pitch as the sound will vibrate, producing a sound of its own.

Experiment: Sympathetic Resonance:

1. Fasten two steel wires securely on a bridge at one end of a long board. Into the other end of the board insert two screws about two inches apart.

Fasten the wires to these screws and tighten the wires by turning the screws until they produce the same pitch. This instrument is called a **sonometer.**

Place on one string a piece of paper folded into a "V" shape, called a **rider.** Set the other string vibrating. If the two strings are tuned exactly alike, the string with the rider on it will begin to vibrate sympathetically.

2. Stand in an empty room and produce a sound, gradually changing the pitch until the correct pitch is struck. The empty room will then seem full of sound. If the room is round or has a spherical ceiling, a great deal of sound will be obtained. All corners, angles, and pockets will respond when the proper pitch is struck. Not only do empty rooms respond to the proper pitch, called the **fundamental or natural tone,** but also to its harmonics, the third and fifth tones, which will be about one-half as loud. If the fundamental is **do** the third harmonic is **me** and the fifth **sol.**

3. Release the loud pedal on the piano and strike the key C. Immediately place a finger on the strings of C which are vibrating and listen to the sympathetic tones produced.

If two tuning forks of the same pitch be placed at the right distance apart, and one fork caused to vibrate and then suddenly stopped, the other fork will be heard producing a sympathetic tone.

Sympathetic Noise.—Very often a piece of metal is caused to rattle by the playing of some note on the piano or the sound vibrations produced by a cornet. Teaspoons in a glass holder or in a pan may rattle enough to be heard some distance. A piece of metal like a teaspoon, ring, or pair of scissors placed on a table may also produce sympathetic noise if the right pitch is struck.

Piano tuners may experience difficulty in tuning a piano because of a vase or other object in the room which may vibrate in sympathy with some tone.

Experiment.—Fasten a small pan to a spring and wire by attaching a pail to the pan. Fasten the wire to the ceiling or to some convenient object so that it will move freely. Place a few pieces of shot or small pebbles or coarse sand in the pan. Blow on a cornet, changing the pitch until the material inside the pan is made to jump about. This experiment illustrates sympathetic noise.

Sympathetic Vibration of Tuning Forks.—If two tuning forks, fastened to resonance boxes as shown in the illustration, are placed at the proper distance apart, the sound waves will vibrate in perfect conjunction, and the sound produced will be twice as loud as that produced by one fork. If the forks be placed at such a distance that the two sound waves do not meet in perfect conjunction, the

vibrations produced will interfere in such a way as to annihilate the sound, and the result will be silence.

Singers very often find difficulty in striking a familiar pitch because some instrument or wall of the room or pocket in the room produces a resonance which causes the singer to respond sympathetically, pitching the voice lower than was intended. A slight change in position will often remedy this trouble.

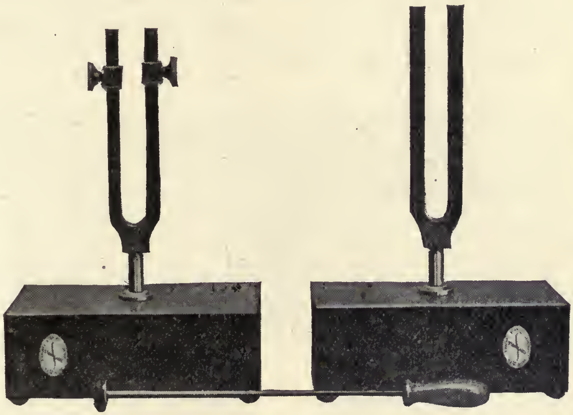


Fig. 308.—If one fork is struck the other will begin producing a tone in sympathy with the first.

Sounding Board.—Most stringed instruments are placed upon some type of board to cause the air to vibrate, usually on a hollow box called a resonance box or sounding board. The piano strings are stretched over a sounding board. The vibrations of the string are transmitted through the frame to the sounding board, forcing it to vibrate with the strings. Since the sounding board is so much larger than the strings, it is able to set a large amount of air in vibration. This the string alone would be unable to do.

Wood in Musical Instruments.—It is important for the piano maker to select wood having tonal value, " singing wood," as it is sometimes called. This really means wood which is responsive. Some woods are not responsive. If struck with a hammer they do not give any tonal value. Pine and spruce are examples of wood

having tonal value. In this wood are little cup-shaped discs. In the center of each of these discs is a small membrane (*l*) similar to the membrane of the ear or phonograph sound box, having a thickened part (*pl*) in the center. It is this vibrating membrane that gives tonal value to the wood. There are millions of these membranes in every square inch of pine or spruce.

It is exceedingly important that a pine or spruce tree after being cut down be properly cared for. It must be air seasoned. If the delicate membranes of the wood are ruptured through carelessly kiln drying it, the tonal values will be destroyed.

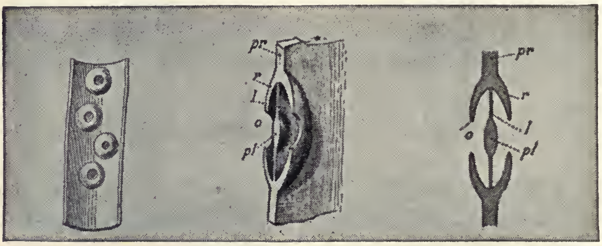


Fig. 309.—Cells in wood used for a musical instrument magnified 250,000 times.

Simple and Compound Tones.—Simple tones are produced by a body vibrating as a whole.

In the illustration, Fig. 310, a diagram of sound waves is shown produced by a tuning fork vibrating as a whole, producing a fundamental. Piano strings not only vibrate as a whole, but in parts. Fig. 311 shows the string of a violin vibrating as a whole, and vibrating in many parts at the same time. The vibration of the whole string produces the fundamental tone which determines the **pitch.** The many little vibrations of the string produce tones above the fundamental which are called **partials** or **overtones.** Fig. 312 shows sounds produced by vibrations as a whole and in many parts. The partials or overtones give tone quality and richness.

A heavy bass piano string about 10 feet in length may be obtained from the American Steel and Wire Corporation. This will show the vibrations of a piano string and its fundamentals and overtones plainly enough to be seen by every member of the class.

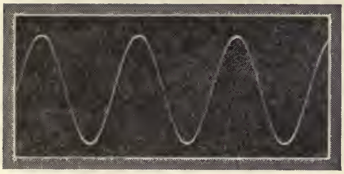


Fig. 310.—Tuning fork. The tone of a scientifically mounted tuning fork is absolutely devoid of partial tones. Hence the tone-wave it creates is entirely free from the irregularities found in other tone-waves which are caused by their partial-waves.

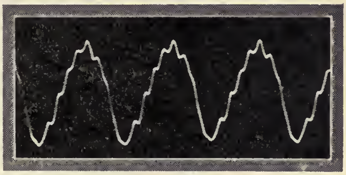


Fig. 311.—Violin. The tone of the violin has many partial-tones. None of these is aggressively dominant, however, hence the fluent, smooth, quality of the instrument. This is shown in the photograph of its tone wave. There are many irregularities in the wave, but they are all too small to influence its general symmetry.

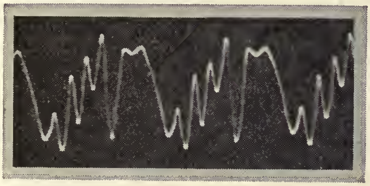


Fig. 312.—Oboe. Here we have a tone-wave which shows unmistakably a tone of very distinct individuality. The pronounced irregularities of the oboe's tone-wave are caused by the dominance of certain of its partial tones.

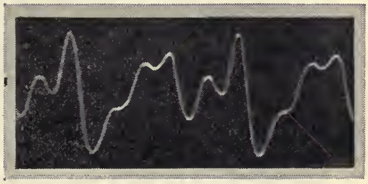


Fig. 313.—Human voice. This tone-wave was created by pronouncing the vowel sound "Ah." The voice is particularly rich in partial-tones, some voices, indeed, containing as many as 40 that are distinguishable.

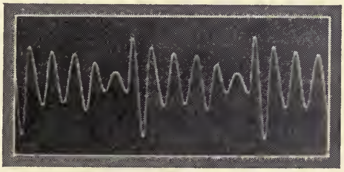


Fig. 314.—Horn. This instrument has a strong fundamental with many partials.

Photographs of the tones of Musical Instruments.

Where the Hammer Strikes the Piano String.—The hammer of a piano strikes the string a few inches from one end. (One-seventh

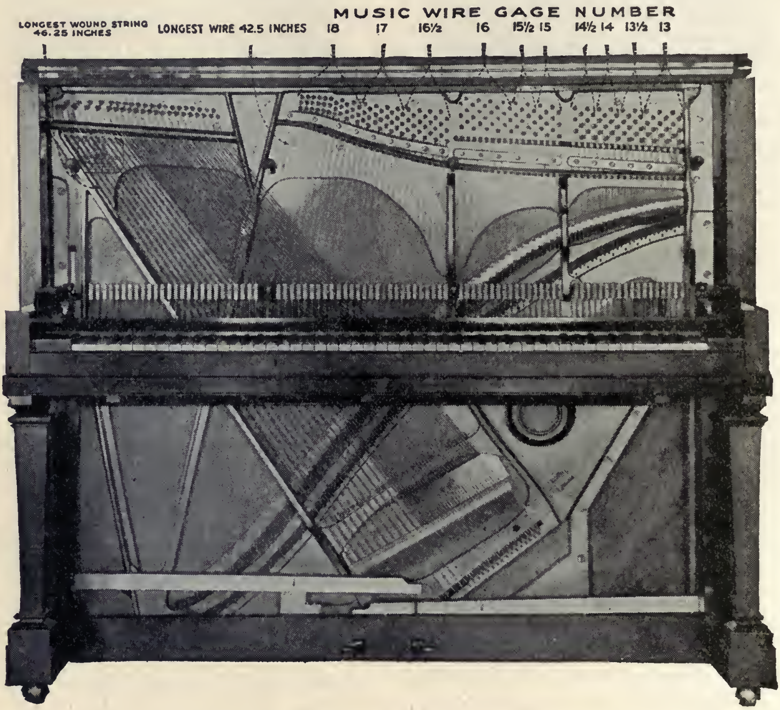
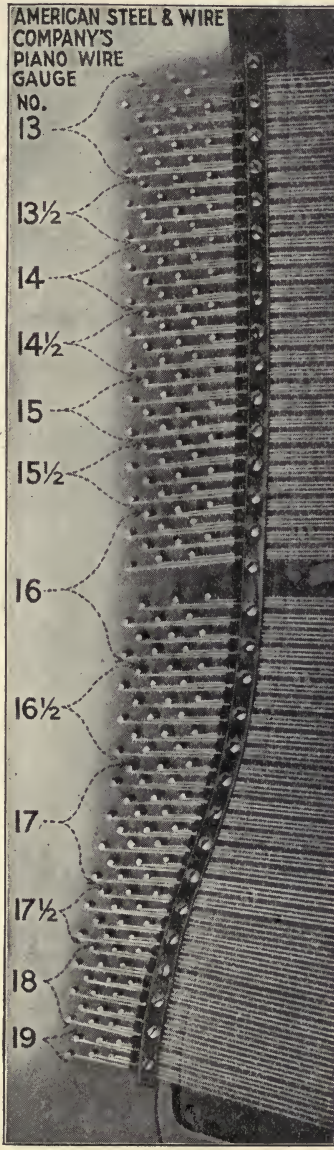


FIG. 315.—This upright piano scale has 160 pounds stress to each string. Why are the strings very short and of small gauge on the right? Why does the length and gauge increase for strings near the center? Why are bass strings wound? How does the number of vibrations of middle C of a piano compare with the number of vibrations of the octave above middle C? Two octaves above? What is necessary, then, to produce a tone one octave higher? Compare the length of the string of middle C with the length of the string two octaves above middle C; three octaves above middle; with the last C.

of its length from the end.) If the hammer struck the string in the center only, a simple tone would be obtained, that is, the fundamental tone. Since the hammer strikes the string near the end,

the string vibrates as a whole, in thirds, and in fifths, which produces partials, resulting in a fine degree of quality depending upon the number of partials blending with the fundamental. If the string of a piano is struck too near the end a "nasal" tone is produced which is not as pleasing to the ear.

Fundamental or Overtone.—Briefly, all tones are divided into groups of tones, each having a different number of vibrations. The various tones are called **partial tones,** and the one having the lowest number of vibrations is called the **fundamental,** while the others are called the **overtones.** As a rule, the fundamental predominates, but with bells the overtones predominate. If the overtones have vi-



Key	Vibrations per Second	Length of String in Inches
C	4138.440	2.0627
B	3906.168	2.1854
A♯	3686.931	2.3153
A	3480.000	2.4530
G♯	3284.682	2.5988
G	3100.328	2.7534
F♯	2926.320	2.8199
F	2762.078	2.9875
E	2607.054	3.1652
D♯	2460.732	3.3534
D	2322.620	3.4406
C♯	2192.262	3.6452
C	2069.220	3.8619
B	1953.084	4.0916
A♯	1843.466	4.2194
A	1740.000	4.4703
G♯	1642.341	4.7361
G	1550.164	5.0177
F♯	1463.160	5.1883
F	1381.039	5.4969
E	1303.527	5.8237
D♯	1230.366	6.1700
D	1161.310	6.3222
C♯	1096.131	6.6981
C	1034.610	7.0964
B	976.542	7.5184
A♯	921.733	7.7571
A	870.000	8.2184
G♯	821.170	8.7071
G	775.082	9.2248
F♯	731.580	9.7733
F	690.520	10.3545
E	651.764	10.9702
D♯	615.183	11.6225
D	580.655	11.9786
C♯	548.065	12.6908
C	517.305	13.4455
B	488.271	14.2450
A♯	460.866	15.0920
A	435.000	15.9895
G♯	410.585	16.5211
G	387.541	17.5035
F♯	365.790	18.5443
F	345.260	19.6470
E	325.882	20.8153
D♯	307.591	22.0531
D	290.327	23.3644
C♯	274.032	24.7537
C	258.652	25.5366
B	244.135	27.0551
A♯	230.433	28.6639
A	217.500	30.3683
G♯	205.292	31.4492
G	193.770	33.3192
F♯	182.895	35.3005
F	172.629	37.3996
E	162.941	39.6235
D♯	153.795	41.9796
D	145.164	42.3729
C♯	137.016	44.8926

FIG. 316.

brations which are exact multiples of the fundamental, they are called harmonics.

International Standard Pitch.—All musicians have agreed that middle A of the violin shall be produced by 435 vibrations per second. Instruments tuned to this A, with other tones having the proper ratio, are said to be tuned to International Standard Pitch.

Tones from String Instruments.—All string instruments depend for their tones upon the size of their strings, the length, and the

Fig. 317.—This instrument has been a favorite in all generations because of the wide range of expression which may be produced. What would be the difference in the tone if the strings of the harp were plucked in the center?

tension of the strings. For example, the strings which produce the bass notes of a piano are large and long, while those which produce high tones of a piano are short and of smaller diameter. The tone is maintained by causing a certain tension of the string. If the tension is reduced, it is necessary to tighten the string.

Experiment.—Notice the effect of tightening the string on a sonometer, also the effect of shortening the string, and, if possible, the effect upon two strings

of different diameters having the same tension. This last may be observed by attaching two strings about 2 inches apart to a board and allowing the end of the string to run over a bridge on the edge of the table. Attach the same weight to each string.

Vibrating Instruments.—The bell, cymbals, drum, tambourine, and xylophone are examples of vibrating instruments. These vibrators are supported usually at the nodes so that vibrations take place freely about the support.

Electro-pneumatic Pipe Organ Key Action.—Figs. 319–320. The key—held in position by the center rail pin and guided by the front rail pin—being depressed, draws the flat wire springs into contact through the platinum points, thus closing the circuit. The magnet draws the leather-covered iron disc from the vent, thus permitting the collapse of the pneumatic.

By means of the flat wire clip and the round wire stem the valve above is opened and the freed air pressure (pneumatic wind) raises the leather membranes which in turn open the pipe wind valves. If the stop action (not shown here) has admitted the pipe wind to the chest the pipe speaks.

The wind supply is automatically controlled by a regulator composed of a weight resting upon the reservoir and a lever valve or a rheostat lever connected by a pliable, galvanized wire rope.

It readily will be observed that a large part of the mechanism is made from round or flat wire, ranging in size from the music steel spring wire $\frac{4}{1000}$ inch in diameter to the bellows feeder shafting having a diameter of from $\frac{1}{2}$ inch to 3 inches. Wire is even more in evidence in the stop and combination actions, making altogether a total of nearly 500 miles of round and flat wire in a modern three-manual organ; and the progressive pipe-organ builder daily finds further substitution of wire for wood and castings efficient and economical.

Human Voice.—The human voice is produced by a simple reed instrument located at the top of the trachea. The place is marked by the Adam's apple. Thin projecting membranes called vocal cords are situated on each side of a slit. These are very loose when a person is breathing, but when one wishes to speak muscular action takes place, bringing the vocal cords close together so that the air from the lungs when forced against them causes them to vibrate. The pitch of the voice depends upon the muscular tension of the cords, while the intensity depends upon the force of air and the position of the mouth and throat. The mouth, throat, and nose

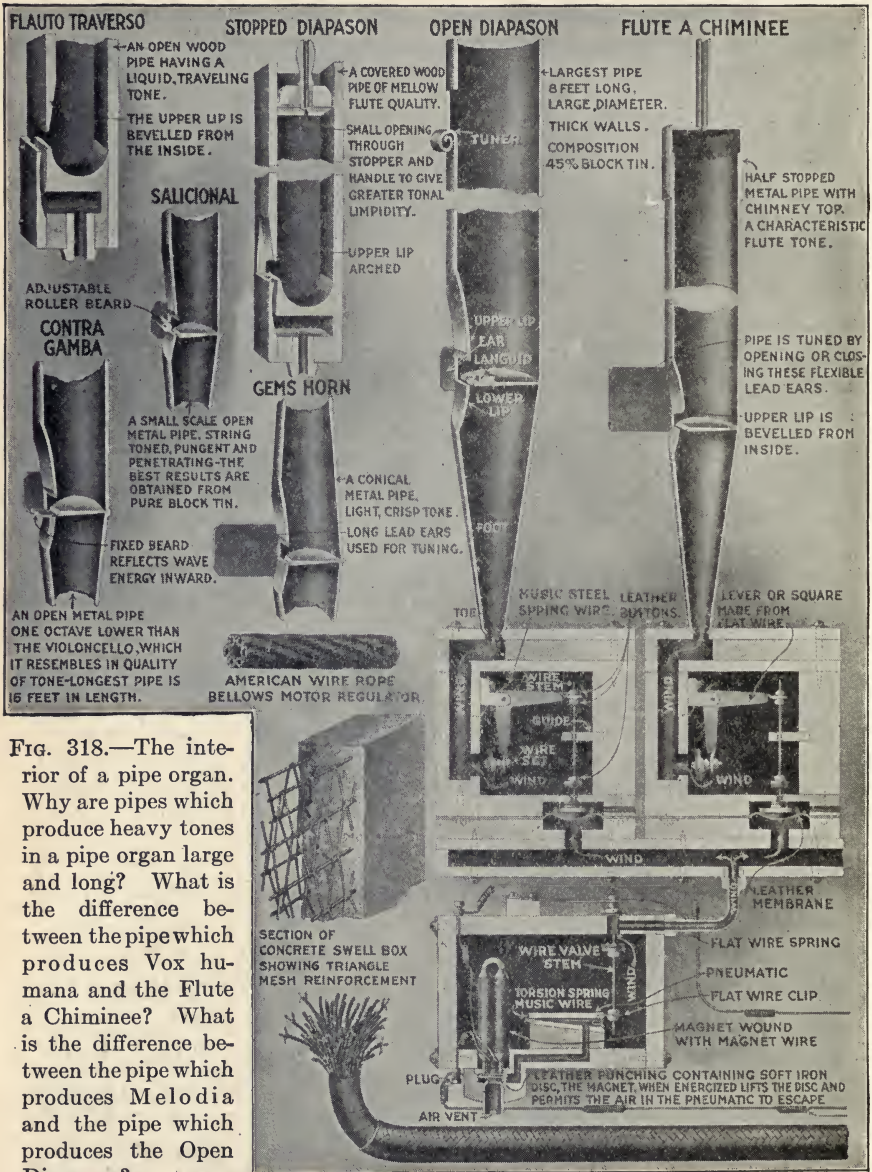


Fig. 318.—The interior of a pipe organ. Why are pipes which produce heavy tones in a pipe organ large and long? What is the difference between the pipe which produces Vox humana and the Flute a Chiminee? What is the difference between the pipe which produces Melodia and the pipe which produces the Open Diapason?

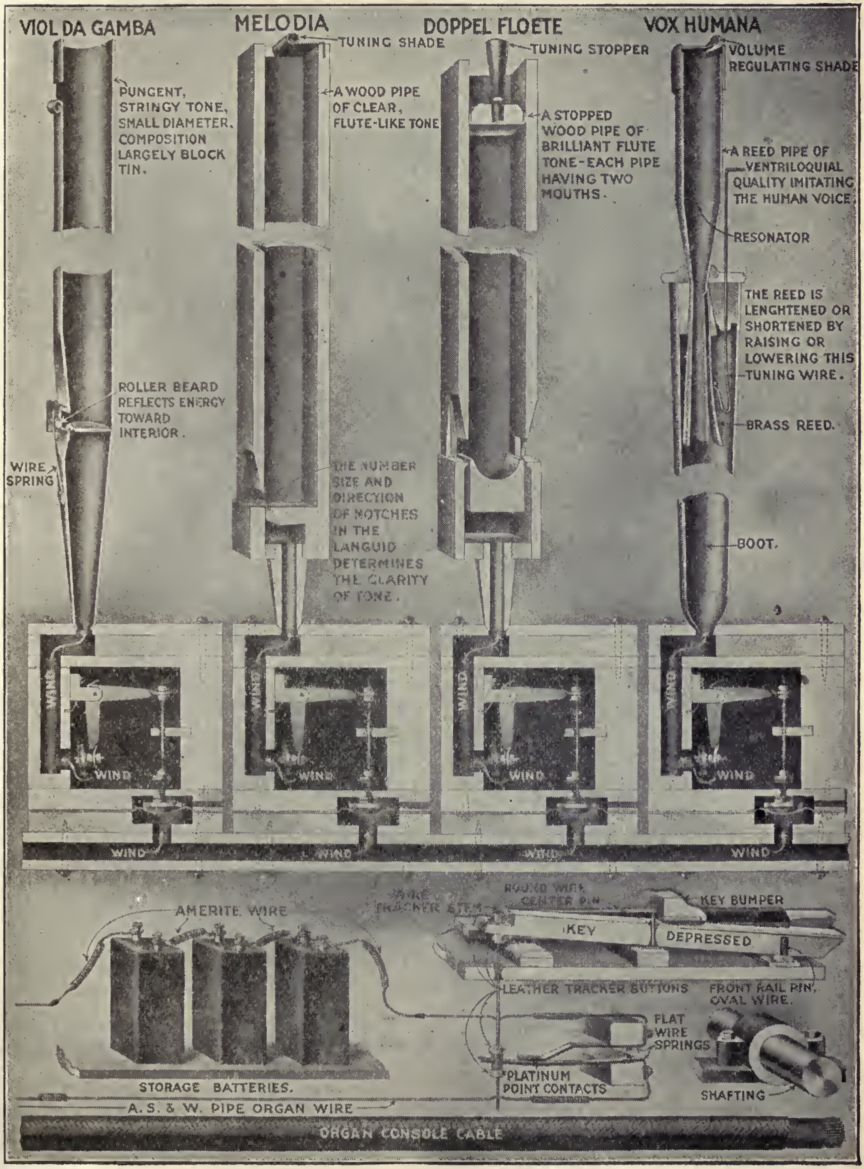

VIOL DA GAMBA
MELODIA
DOPPEL FLOETE
VOX HUMANA
TUNING SHADE
TUNING STOPPER
VOLUME REGULATING SHADE
PUNGENT, STRINGY TONE, SMALL DIAMETER, COMPOSITION LARGELY BLOCK TIN.
A WOOD PIPE OF CLEAR, FLUTE-LIKE TONE
A STOPPED WOOD PIPE OF BRILLIANT FLUTE TONE-EACH PIPE HAVING TWO MOUTHS.
A REED PIPE OF VENTRILOQUIAL QUALITY IMITATING THE HUMAN VOICE.
RESONATOR
THE REED IS LENGHTENED OR SHORTENED BY RAISING OR LOWERING THIS TUNING WIRE.
BRASS REED.
ROLLER BEARD REFLECTS ENERGY TOWARD INTERIOR.
WIRE SPRING
THE NUMBER SIZE AND DIRECTION OF NOTCHES IN THE LANGUID DETERMINES THE CLARITY OF TONE.
BOOT.
WIND
AMERITE WIRE
KEY BUMPER
KEY
DEPRESSED
LEATHER TRACKER BUTTONS
FRONT RAIL PIN, OVAL WIRE.
FLAT WIRE SPRINGS
PLATINUM POINT CONTACTS
SHAFTING
STORAGE BATTERIES.
A. S. & W. PIPE ORGAN WIRE
ORGAN CONSOLE CABLE

Fig. 319.

act as a resonant box which, by automatically changing its form and size, causes different qualities of tone.

Fig. 320.—One of the largest pipe organs in the world. Why is it necessary to have long and short pipes? What kind of tones do you think the long pipes would produce?

Piano Player.—Piano player action depends upon the atmospheric pressure. The hammers are made to strike the strings of the

piano by drawing the air from the mechanism. The perforated paper roll passes across the tracker bar which consists of a series of openings each one of which corresponds to a hammer or note on the piano. When a perforation in the paper passes over the opening the air rushes in, causing air pressure on that part of the piano which will cause the hammer to strike the proper string. The air pressure is produced by an air pump (exhaust pump) worked by the feet. The harder a person pumps, the greater vacuum is created behind the paper roll passing over the tracker.

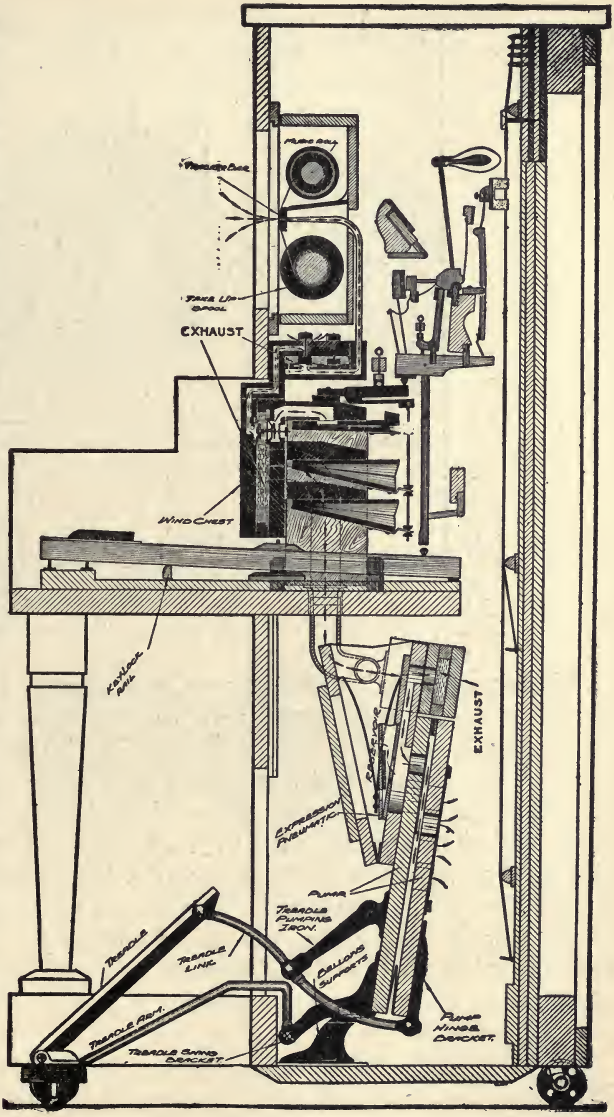


FIG. 321.—Mechanism of a Piano Player.

Courtesy of the Autopiano Company.

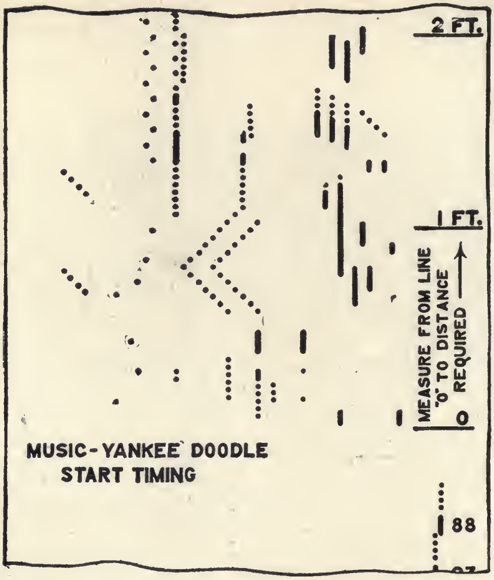


FIG. 322.—A section of a music roll for a player piano.

Courtesy of the Autopiano Company.

Phonograph.—Whenever a needle or sharp instrument is attached to a disc and sound waves strike the disc or diaphragm, the disc will vibrate, causing the needle also to vibrate. If the point of the needle is drawn along over some soft material, the vibrating needle will leave impressions in the substance. This is exactly what happens when a record is made for a phonograph. If a person sings into the large end of a horn, the sound waves will be collected at the small end. If a disc is placed at the small end of the horn and a needle is attached to the disc, the disc will vibrate, causing the needle to vibrate and cut grooves in any soft substance. When the soft material is moved along at uniform rate the sound waves will be recorded.

Now, if a needle, to which is attached a disc or diaphragm, is allowed to run in the little grooves which have been made on the wax, a sound will be produced like the sound of the voice which spoke in the horn. Since this wax is too soft to retain its

shape, a hard substance must be made. The soft wax is copper plated, the plate taking all the impressions which were made on the soft wax. Duplicates of this plate are now used to stamp

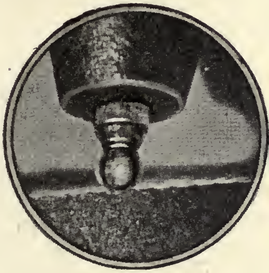


Fig. 323. Fig. 324.

Fig. 323.—A diamond point for the reproducer.
Fig. 324.—A needle attached to the reproducer.

Courtesy of Scientific American.

or print records in material which is warm and soft, but which upon cooling will become very hard.

Records look like rubber, of which they were originally made, but

Figs. 325. and 326.—The figure at the left shows a new steel needle. The figure at the right shows a steel needle used once (magnified 25 times). Why must the needle be changed for each time a record is played? Area of needle-end is $\frac{1}{36000}$ sq. in. (average). About $\frac{1}{500}$ of the thickness of the needle is worn off for a large record. Notice the knife-edge, which will do a great deal of harm to a record.

Courtesy of the Scientific American.

are now made from "mud." Shellac, china clay, talcum powder, coloring matter, barium, asphalt and cotton flock are the principal materials used in making a record. Some manufacturers use earth, rotten stone, powdered silica, and metallic oxides.

Shellac makes the mixture of equal consistency and the cotton flock holds the material together much as hair does in plaster.

An Edison record is made from cheap pulp covered with a veneer of condensite made from carbolic acid and formaldehyde and many

FIG. 327.—A phonograph record.

FIG. 328.—Thomas A. Edison

other chemicals. This material meets the chief requirements of a record. It is soft when warm, readily taking the impression of the die. It is very hard when cooled and expands or contracts very little from heat or cold.

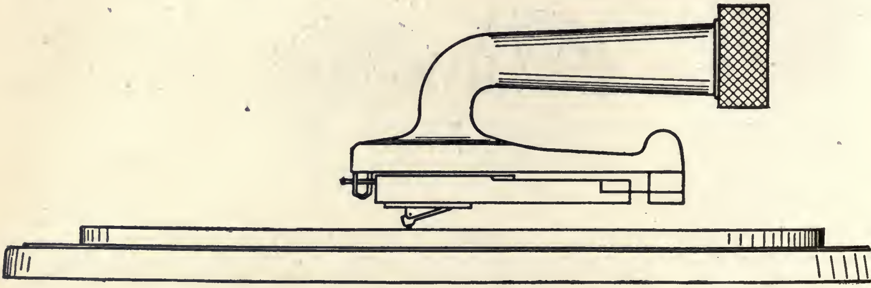


FIG. 327*a*.—The reproducer and record on the turn table.

There are two types of recorders, one which cuts records up and down, called the "Hill and Dale" method, and the other the "Lateral Cut" which cuts the record in a side to side motion.

There are two types of reproducers. Some phonograph companies use needles made of steel and wood, others use rounded

stones, such as diamonds and sapphires. The needle or stone runs in the groove which was produced by a recorder. Large needles are sometimes used to produce great volume of tone. Needles of this type soon ruin a record, as the weight and resistance of the needle passing over the tiny undulations on the record wear them down quickly. The needle or stone is attached to a diaphragm which is caused to vibrate by the impressions made on the record.

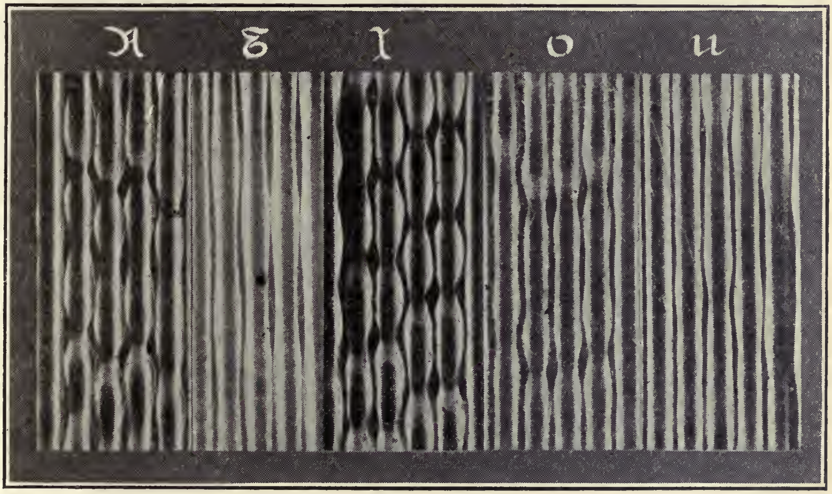


FIG. 329.—A section of a record produced by a tenor voice singing the letters *a*, *e*, *i*, *o*, *u*. Magnified.

This diaphragm causes sound waves which imitate the human voice, or other sounds which were recorded on the original record. The record is turned under the needle by a spring which must be wound up from time to time.

Telephone.—Sound waves striking a thin membrane or disc cause the membrane or disc to vibrate. This principle is used in the human ear. The ear drum is a thin membrane which vibrates when sound waves strike it, sending vibrations through the auditory nerve.

Alexander Graham Bell got his idea of the telephone from the vibrating membrane in the ear. He thought it would be possible

to cause an iron membrane or disc to vibrate when sound waves struck it; and if the vibrations of this membrane could cause electrical currents to pass over a wire and make another membrane vibrate exactly like the first membrane, a person listening at the other end would be able to hear the membrane producing sounds like the human voice. The telephone is made on this principle

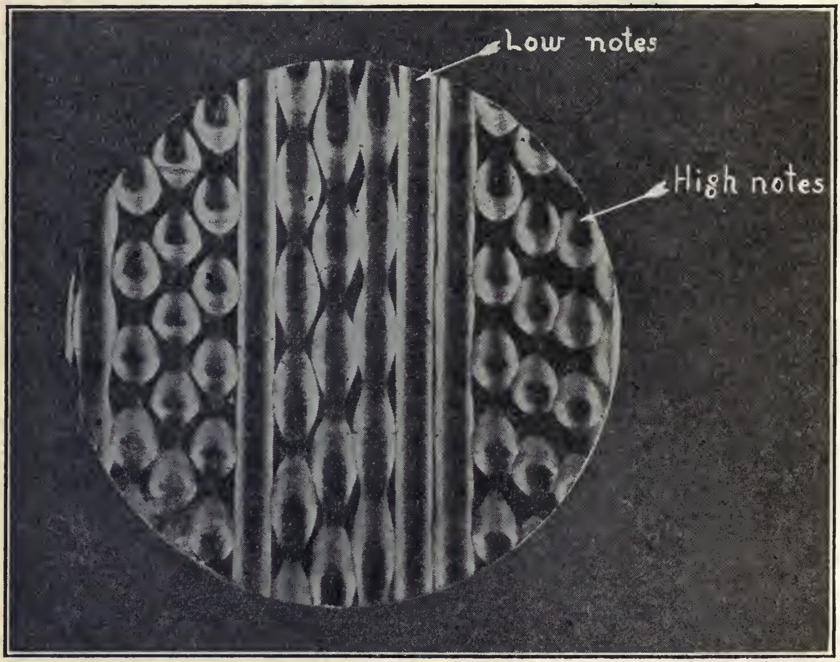


Fig. 330.—A section of a record produced by a soprano voice. Magnified.

In other words, a solid metallic body takes up from the air countless varieties of vibrations produced by speech, and these vibrations are carried along the wire by means of electricity, and are reproduced exactly by another metallic disc on the other end of the wire. Of course it is not the sound which actually travels over the wire. Electrical currents are caused by the vibration of the disc

in front of an electric magnet, of which we have learned in the last chapter.

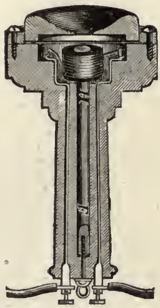


FIG. 331.—X-ray telephone receiver.

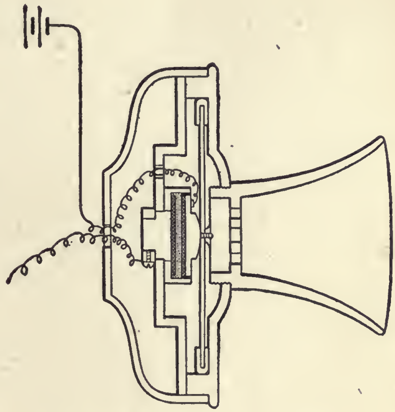


FIG. 332.—Telephone transmitter.

These currents cause the disc on the other end to vibrate, because of the attraction of the disc to the magnet, according to the

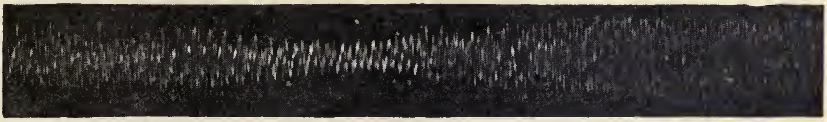


FIG. 333.—Some of the changes in the electrical current which take place on the telephone circuit when the word "San Francisco" is spoken into the telephone.

FIG. 334.—Some of the changes in the electrical current which take place in the telephone circuit when the word "New York" is spoken into the telephone.

increase and decrease in the strength of the current passing over the wire. If the sound waves could travel from New York to San

Francisco a person in New York would not hear his friend speak in San Francisco until four or five hours after he had spoken. The time required for electrical currents to carry vibrations from New York to San Francisco is one-fifteenth of a second.

Visit the telephone central office in your town and have the workings of the telephone explained to you.

Read the "History of the Telephone" by Herbert N. Cason, published by A. C. McClurg & Co., Chicago, Ill.

CORRECT TELEPHONE HABITS

On All Outgoing Calls

Always look in the telephone book to **make sure** you call the right number. If you do not find the number in the book, ask "Information."

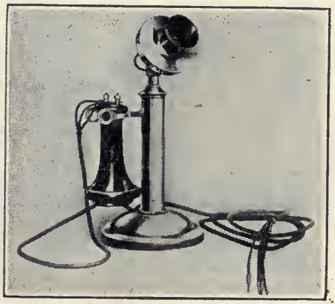


Fig. 335.—The way you talk over the telephone often tells something about your character.

Call **this number** with a slight pause between the hundreds and the tens. For example, in calling "Barclay 1263," say, "Barclay One Two (pause) Six Three.

Speak **clearly** and **distinctly,** directly **into** the transmitter.

Listen to the operator's repetition of the number and acknowledge it.

Hold the line until your party answers, and then give your whole attention to the telephone conversation.

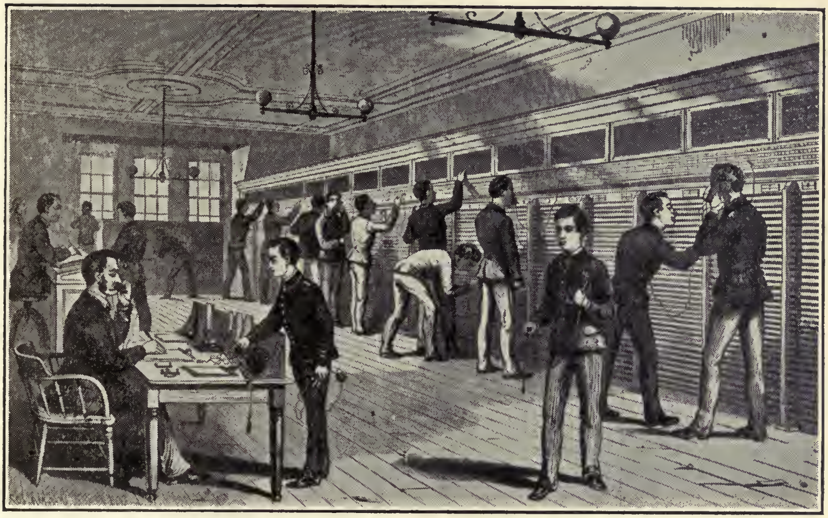


FIG. 336.—An early telephone exchange. When telephone exchanges first appeared boys were employed to make the connections.

FIG. 337.—The modern telephone exchange. Why do you think girls were substituted for boys?

To recall the operator, move the receiver hook up and down **slowly.**

When you have finished talking, say "Good-bye" and replace the receiver on the hook.

Remember, courtesy over the telephone is always desirable. It wins friends for you.

On All Incoming Calls

Answer your telephone **promptly** and **pleasantly.**

Announce your name. Don't say "Hello."

Be ready with pad and pencil in order not to keep your caller waiting.

Listen attentively so that you will not have to annoy the caller by asking him to repeat.

Maintain the same courtesy and consideration in a telephone conversation that you would in the person's presence.

"The voice with the smile wins."

Questions

1. Why does a person hear another if the speaker uses his hands as a trumpet?
2. Why should a piano string be struck a few inches from the end of the string?
3. Why does a dog prick up his ears when he hears a sound?
4. Of what advantage is it for a person to place his hand behind his ear when trying to hear a faint sound?
5. Of what use is the horn on a graphophone?
6. Why do announcers often use a megaphone?
7. Why is a piano string struck one-seventh of its length from the end?
8. What stops the string from vibrating after it is struck hard by the hammer?
9. What can you do to keep the string vibrating some time after striking the key on the piano? Examine what happens inside the piano by watching the hammers and the result of using the different pedals?

10. What does the soft pedal do to reduce the loudness of the tone?

11. How does the violinist tune his violin?

12. How does he produce high and low pitches on the same string?

13. Why does a violin have a hollow box under the strings?

14. Why is there an opening in the box?

15. Why do some violins produce more beautiful tones than others?

16. Of what kind of wood is the violin made? Why?

17. Why are old violins said to be better than new violins?

18. Why does a string over a sounding board cause a louder tone than a string vibrating alone?

19. Why are bass horns in the band larger than any cornet?

20. How does the musician produce different pitches on a slide trombone?

Fig. 338.—By varying the tension of the lips and the pressure of breath in addition to the use of the tongue, all the notes of the scale may be produced.

Fig. 339.—What causes the sound in the drum? Why is it so large and hollow? Why does changing the position of the fingers on the holes change the pitch of the fife?

FIG. 340.—Violin. How are high and low tones produced on the violin?

FIG. 341.—Why is it necessary to change the position of the left hand?

FIG. 342.—Xylophone. Why are the pieces of metal of different size?

FIG. 343.

21. Why should you never leave the telephone receiver off the hook?

22. Why is it unfair and discourteous to use the telephone for a long time talking about unimportant things?

23. Who is usually more courteous over the telephone, you or " central "?

24. What parts of this chapter do you find useful to you?

CHAPTER XIII

THE UNIVERSE

LAWS OF MATTER

Molecules.—All objects are made up of tiny particles of matter called **molecules.** They are so small that no one has been able to see them. Scientists believe that they exist because there are so many evidences of their existence in the natural laws of science. All bodies are made up of these molecules which, in turn, are made up of tiny particles, called **atoms,** which are still further subdivided. We call this a theory, since we have not absolutely proved the fact that molecules do exist.

We know that when a teaspoonful of sugar is placed in coffee, the sugar disappears, but if the sugar were placed in water, the water could be boiled away, and the sugar would be found to have returned to its original appearance.

It is believed that the little grains of sugar break up into their molecules and separate throughout the liquid. They are so small that they can not be seen; however, the sugar may be tasted, since it has sweetened the entire cup of liquid. We commonly say the sugar has dissolved.

This is called the **molecular theory.** These molecules, like the bodies in space, attract each other with a great deal of force. If the body is in liquid form and free to act, the molecules pulling toward each other tend to pull the body into a spherical form. An example of this tremendous attraction of the molecules for each other may be seen in a glass of water.

Cohesion.—Experiment. Carefully place a dry needle on the surface of a glass of water. It will float.

There seems to be a toughened place on the surface of the water. Every molecule of water is pulling every other molecule with a

tremendous force, but the molecules on the top of the water are pulled up by only the molecules of air whose attraction is not as strong as that of the molecules of water underneath; therefore, the molecules on the surface of the water are pulled down into the water with a greater force than they are pulled upward from the water, which causes them to crowd together so closely as to form a toughened place on the surface of the water on which the needle may rest.

We call this force which pulls together molecules of any substance **cohesion.** Cohesion is very important to our life. Pieces of wood stick together because the molecules of the wood attract each other, and the stronger the cohesion is between the molecules, the harder it is to break the body apart. If a piece of crayon is broken, it is very difficult to stick the pieces together so that they will hold. If we press very hard, we may get the molecules near enough together to cause them again to attract each other. The distance between the molecules before attraction takes place must be within a millionth of an inch.

Impenetrability.—If we tear a sheet of paper in two we really do not tear the paper but simply separate the molecules. This is also true when we drive a nail into a board. The nail does not pass through the board, but between the molecules, separating them, sometimes sufficiently to cause the board to split. This property of matter is called **impenetrability,** which means that nothing can be penetrated. We do not drive nails into wood, strictly speaking.

Adhesion.—It is often necessary to use glue or cement to mend a piece of wood or china which has been broken. Sometimes the molecules of one substance are attracted with a great deal of force toward the molecules of another substance. For this reason, two pieces of wood which must be mended are covered with glue and then tightly pressed together to get the molecules of glue as near the wood as possible. This is called **adhesion.**

If the molecules of one substance have a great attraction for the molecules of another substance the two substances will adhere. Water, for example, will separate over the table because the molecules of the wood have a greater attraction for the molecules of the water than the molecules of water have for each other.

Mercury, however, will form into globules without moistening

the table because the attraction of the molecules in the wood is not as strong as the attraction which the molecules of mercury have for each other.

For this reason dishes may be washed in water, crayon will stick to the blackboard, syrups are purified by filtering through animal charcoal.

Observe the action of mercury and water on the top of glass, wood, paper, and wood covered with chalk dust.

Capillarity.—We all know that certain blotters take up ink much more quickly than others. This is due to the strong adhesion between the liquid and the solid. Some solids attract certain liquids with a great deal of force. The solid is made loosely with openings which allow the liquid to run in between the particles of the solid. Kerosene rising in a lamp wick is another example of a liquid being attracted by a solid.

Place a drop of ink on a piece of glass. Put a piece of lump sugar in the ink. The ink will quickly run up the sugar to the top in the little spaces between the particles of sugar. This is called **capillarity** (capilla, a hair), since long glass tubes with hairlike bores cause a liquid, such as water, to rise in the tube to some height.

Indestructibility.—The atoms which make up molecules can not be destroyed. We may manufacture paper from wood. We have not destroyed the atoms which made up the molecules of wood. We have simply reunited them, producing a different substance. In the burned paper we still have not destroyed the atoms. Some have passed off in smoke, others remain as ashes, but whatever they were in the original wood, atoms of Hydrogen, atoms of Oxygen, or atoms of Carbon, there are still atoms of Hydrogen, Oxygen and Carbon which are producing new substances. This inability to destroy any matter is called **indestructibility.**

Other Properties of Matter.—Matter has several other properties. One is **porosity**, which allows other substances to enter between the molecules. The molecules of salt and sugar are capable of getting into the spaces between the molecules of water.

Ductility.—A property of matter which allows certain types of material to be drawn out, such as wire.

Malleability.—A property of matter which permits substances to be pounded into thin sheets. For example, gold is very malleable. It may be pounded into a sheet as thin as $\frac{1}{360000}$ of an inch thick.

Tenacity.—A property of matter which prevents bodies from being easily pulled apart.

Elasticity.—A property of matter which causes it to resume its original shape after some force has given it another shape. Steel, rubber, glass, ivory, etc., are very elastic.

Hardness and Softness.—Properties of matter which are well known to us. The diamond is the hardest known substance.

Brittleness.—A property of matter which allows matter to be easily broken. Glass, china, etc., are good examples.

Solutions.—Place a crystal of potassium permanganate in a flask of water. The permanganate will slowly dissolve and color the liquid red.

The dissolving of the permanganate illustrates the attraction of the molecules of water for the molecules of potassium permanganate. Sugar for sweetening coffee and salt for seasoning food are other illustrations of this molecular attraction. Water dissolves many substances, but there are substances which are not dissolved by water. Water is called a **solvent.** Different liquids have different solvent powers. Grease is not dissolved by water but by benzine, beeswax by turpentine, resin and shellac by alcohol. For cleaning, for preparing paint, and many other things, it is necessary to know the proper solvent for different substances.

Absorption of Gases.—The molecules of many substances attract the molecules of gases. Butter will have its flavor affected if any substance is placed near it which is sending off a gas or odor. Water absorbs air. Carbon dioxide is forced into water to produce soda water. Heating substances which have gases dissolved in them very often drives the gases off. Little bubbles of air may be seen collecting on the inside of a glass of water which is standing in a room.

Crystallization.—Any substances which have been dissolved in a liquid will return to a solid state if the liquid is evaporated. Evaporation of the liquid is an example of the molecules of a liquid escaping

as a gas. An example of this may be seen in the evaporation of a liquid (sap) obtained from maple trees which leaves behind maple sugar. If sea-water is heated until the water evaporates, salt is left behind.

Dissolve about one ounce of alum in a cup of hot water. Hang two or three strings in the solution. As the solution cools, crystals will form on the strings. The molecules of alum as they collect arrange themselves in such a manner as to produce beautiful crystals.

Osmosis.—Cut out the interior of a beet or carrot and fill the space with a thick syrup or molasses. Close the top with a rubber stopper through which passes a long glass tube. Place the carrot in a bottle of water.

Water will pass through the walls of the carrot, mingling with the thick liquid. The water will pass into the carrot much faster than the syrup will pass out through the walls. This process of a liquid passing through thin membranes into a thicker liquid is called **osmosis.** Plants get their food and water through the hair roots by this process. Oxygen gets from the lungs into the blood and fish absorb oxygen from the water by means of osmosis.

Inertia.—Inertia is the great force which keeps all bodies in the universe in motion.

We have all experienced a certain force which tends to push us forward if we have been standing in a moving street car which comes to a sudden stop. The tendency which forces us to keep on going in the direction in which the car had been moving is called **inertia.** If we happen to be standing still in the car, and the car suddenly starts, we have a tendency to remain in the same spot where we were standing, which causes us to take a step backward quickly in order to keep our balance.

This force **inertia** is, expressed in simple words, a force which tends to keep moving bodies in motion in the direction in which they are traveling, and resting bodies at rest. Whenever an automobile or car stops, it must overcome the tendency to keep on going. Whenever an automobile or car starts, it must overcome the tendency to remain at rest.

So powerful is this law of inertia and its tendency to make things go in a straight line that railroads must bank the outer rail higher than the inner on curves.

If an automobile goes around a curve too quickly, it is tipped because of the tendency of that automobile to continue in a straight line.

Children playing in the street often forget that it is dangerous to use the public thoroughfare as a playground, since automobiles and cars moving up and down the street can not be stopped instantly by the drivers.

Gravity.—When one drops something from his hand he knows that the object will fall toward the earth. People who go up in aeroplanes know that when they get ready to come back to earth a certain force will pull them downward toward it. Those who jump from balloons know that this force is so great that parachutes are required to counteract the force pulling toward the earth. This force which pulls things toward the earth also holds all objects on the face of the earth. The waters of the sea, the houses, the rocks and the trees are all held on the surface of the earth by a force called **gravity.**

The Force of Gravity Varies with the Size of the Body.—The larger the body or planet the greater is the force of gravity of the body for objects on its surface. The moon is about $\frac{1}{50}$ as large as the earth. The pull of gravity on the moon is so much less than that of our earth that a body weighs only $\frac{1}{6}$ of what it would weigh on the surface of the earth, and a jumper who jumps 5 feet on the earth would be able, expending the same energy, to jump 30 feet on the moon.

Up and Down. Very few of us ever stop to think what "**down**" really means. Objects are said to fall down from any height. We seldom think that if two objects on opposite sides of the world should fall from the same height at the same time, those objects would be moving toward each other or, in other words, toward the center of the earth. **Down,** then, is the direction toward the center of the earth, and the end of "down" is at the center of the earth.

Up is away from the center of the earth, and the beginning of "up" is at that point, while the end of "up" is at a place so high above the earth that the earth ceases to pull the object toward it. For example, if an object could move directly up from the earth toward the moon it would be going up until it reached the place

where the moon attracted it with greater force than the earth; and then it would be falling down toward the moon.

Gravitation.—Gravitation differs from gravity. Gravity means the pull of the earth for all bodies on it. **Gravitation** means the force which tends to draw all objects in the universe toward each other. Large objects have a greater force of gravitation than small objects. The sun, the moon, the planets and stars are all held in their position by this great force of gravitation.

Spherical Forms.—Experiment.—Fill a small bottle about half full of water. Tip it gently. Fill the remaining part of the bottle with alcohol by allowing the alcohol to run slowly down the side of the bottle so that it will not mix with the water, but float on the surface. Drop a large drop of heavy oil into the bottle. Since the oil is heavier than the alcohol, it will sink until it comes in contact with the surface of the water. There sufficient alcohol and water have mixed so that the bubble of oil will rest in the mixture. The bubble of oil will assume a spherical shape. All material in a liquid form will assume a spherical shape if allowed to act freely.

Raindrops have a tendency to be spherical. Shot is manufactured by allowing streams of molten lead to run through fine holes from the top of a shot tower. These fine streams, before reaching the bottom of the tower, break up into little balls of molten lead which cool somewhat and harden before striking water at the bottom of the tower. A splendid example of liquid breaking up into spherical forms may be seen by turning the faucet until only a fine stream may be seen. Half way down the stream of water hundreds of little spheres of water are forming.

Questions

1. Why does one jumping from a height bend the knees on alighting?
2. In starting a load why does a horse have to give a harder tug than he does to keep it moving after it is started?
3. Why do we have great difficulty in stopping when running down hill, especially when carrying a heavy weight?
4. If the valve is suddenly closed after water has been running from the tap why will there be a noticeable thud?
5. Why do automobiles skid when turning corners rapidly?

6. Why do railway coaches " telescope " in a collision?

7. Why can an athlete make a longer running jump than a standing one?

8. Why can a quoit be kept in a plane by giving it a twist?

9. Why can a small boy spill out the occupants of an express wagon by giving the wagon a sudden jerk?

10. Why will a train continue moving after the locomotive has been uncoupled at a flying switch?

11. When a car moves swiftly around a curve, why are the standing passengers moved across the car toward the outside of the curve, although holding to the straps?

12. Why is it possible to fill the tank in the tender of a locomotive, while the locomotive is moving rapidly, by lowering a scoop connected with the tank into a trough of water placed between the rails?

13. Why is it difficult to set in motion the massive doors of a large vault?

14. Why will mud and water leave the rim of a moving carriage wheel in a direction tangent to the rim?

17. Why is it possible to remove snow from the shoes by kicking the feet against the doorstep?

18. When one shovels coal he swings the shovel full of coal forward, then suddenly stops the shovel; why does the coal continue forward?

19. When a street car stops suddenly, the passengers lurch forward; when it starts suddenly, the passengers are thrown backward. Why?

20. When one jumps off a moving street car he is thrown violently to the ground. Why?

21. When a runner " stubs his toe " he falls forward. Why?

22. Why is it possible for a clothing salesman to remove a coat from the bottom of a pile by giving it a quick jerk?

23. If one pulls a plate full of soup quickly toward him, the soup spills out on the opposite side. Why?

24. A bullet thrown against a window shatters the glass; if it is shot through the window it leaves a clean hole. Why?

25. A carpenter tightens the head of his hammer by striking the end of the handle on a beam. Why?

26. What causes the strange feeling when an elevator starts to descend quickly?

27. When the ink does not start from out a fountain pen easily, what may we do? Why?

28. Why is it necessary to start an automobile on low gear?

29. How is it possible for a pitcher to " curve a ball "?

30. Why does snapping a cloth remove the water?

31. Do you beat the dust out of a carpet or the carpet away from the dust? Why?

32. Why do we write so unevenly while riding in a street car or train?

33. Why does the world keep turning?

34. Which way would an automobile tip over going around a curve; to the inside or outside of the curve?

35. Which way would you lean in riding around a curve in an automobile? Why?

36. Is the outside or inside rail on a curve of a railroad banked? Why?

37. Why does dodging help a hare to escape a hound?

38. If two cars met head on going at different rates of speed the occupants of which car would receive the greater injuries?

39. Is there any truth in the statement that it is not the falling any great distance but the stopping quickly that does the injury? Why?

40. Why are we not aware of the rapid motion of the earth?

41. Why is it possible to pass over a piece of thin ice quickly, whereas stopping for a moment will cause the ice to break?

42. Why does a rotary sprinkler rotate?

43. Why does a garden hose which is not straight twist and turn when the water is turned on?

44. What would happen if the world suddenly stopped revolving?

45. Why does the air remain on our earth?

46. Why do the bubbles in a cup of cocoa or tea gather on the side?

47. If an apple falls from a tree does the earth move toward the apple?

48. Why do automobiles tear up the surface of a road?

49. Why do cream separators remove the cream from the milk?

50. Why does cloth shrink when it is wet?

51. Why is it not possible to write on blotting paper?

52. What is done to paper which is to be used as writing paper?

53. Why will camphor dissolve in alcohol and not in water?

54. Why will clothes lines tighten up during a rain storm?

55. Why is it possible to mark on the blackboard with chalk?

56. Why cannot one write as well on glass?

57. Why is there a slit in a pen point?

58. Why does a rough towel dry the body more quickly than a smooth one?

59. Why is it possible to paint wood and iron?

60. Why is it possible to make a mark on paper with a lead pencil?

61. Why is it not possible to write on paper with a slate pencil?

62. Why does salt become damp?

63. Why must pails and tubs made from wood be kept damp?

64. Why do some people place flour on a fresh ink stain on the tablecloth?

65. Why is it almost impossible to remove kerosene or ink stains from marble?

66. Why are lips put on pitchers?

67. Why is it almost impossible to wash greasy hands with water alone?

68. Why is it difficult to untie a wet knot?

69. Why does oil float on water and alcohol mix with water, both liquids being lighter than water?

70. Why does molasses stick to things?

71. Why does glue make things stick together?

72. Why does heating iron make it possible to weld it?

General Questions for Investigation and Discussion

1. Why does one lean forward when climbing a steep hill and backward when descending?

2. When carrying a heavy package in one hand why does one lean toward the opposite side?

3. One leans forward in getting up from a chair. Why?

4. It is difficult to balance a ruler on one end on the finger. Why?

5. When one is standing in a swaying street car he is more secure with his feet farther apart than usual. Why?

6. A tall, slender vase is more likely to tip over than a short, thick one. Why?

7. Why are some inkwells made cone-shaped with thick bottoms?

8. A canoe overturns more easily when a person stands up in it than when the person is sitting down. Why?

9. Why is a wagon loaded with hay more likely to tip over on a hilly road than one loaded with rocks?

10. "Ballast" is placed along the keels of sailing vessels to prevent capsizing. Why?

11. The engines of motor boats are set as low as possible in the boat. Why?

12. Why are some oil cans and inkwells made with round bottoms and loaded with lead at the bottom?

13. As one climbs a steep ladder he has to be more careful as he climbs higher. Why?

14. It is easier to balance a china bowl on the end of the finger when the bowl is upside down than when it is upright. Why?

15. Why is a tail placed on a kite to prevent it from "diving"?

16. Why is a tricycle less likely to upset than a bicycle?

17. If one stands with his heels against the wall and tries to pick up a coin placed between his feet he cannot do so without falling. Why?

18. Why are tall vases sometimes prevented from tipping over by placing sand in them?

19. What is friction?

20. Why can we not push a nail into wood?

21. Why must water be kept continually on a grindstone when grinding knives?

22. Why does a hone sharpen a razor?

23. Why do skates make grooves in the ice?

LOCATION

Direction.—Since the earth turns upon its axis, man has established certain points which are called points of the compass. The earth turns toward the **dawn point** which is called the **east.** The opposite of that direction is called the **west.**

Fig. 343.—Notice the pointers and the earth's axis, each in line with the pole star.

The North Star remains fairly constant over the North Pole of the earth, and is used to determine direction. The common method of determining direction, however, is through the aid of the compass, which consists of a bar of magnetized steel, or needles, so suspended that the bar or card to which the needles are attached will swing freely in a horizontal plane. The bowl of the compass is constructed of copper or brass, and the dial is fitted with an agate cup in the center, placed upon a sharp point to allow the needle or dial to swing freely.

On shipboard the dial floats in alcohol to keep the card level as the ship rolls and pitches. The compass does not point to the North Pole of the earth but to a North Magnetic pole on Boothia Island in Northern Canada. Find the island on the map.

There are a few places in the United States where the compass will point to the earth's true north. The amount of variation between the north pole and the north magnetic pole is called **declination;** and navigating officers must allow for this in working out the true north when sailing. They are provided with government charts which show the exact amount of declination.

Longitude.—The longitude of any place on the earth is measured

east and west of a prime meridian according to the difference between Greenwich and the place. The units of measure are degrees, minutes,

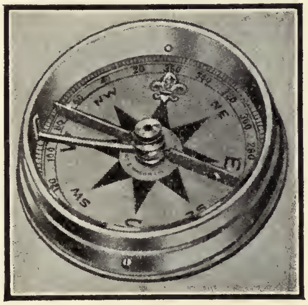


Fig. 344.—A pocket compass.

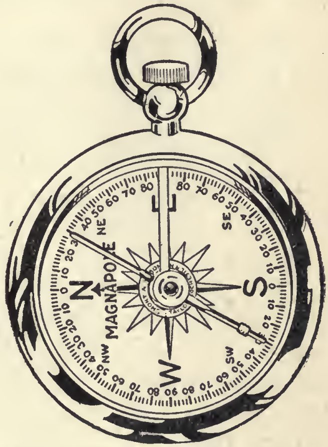


Fig. 345.—A hunter's compass.

and seconds. The distance around the earth is divided into 360 degrees.

The sign for degrees is " ° "; for example, 85°.

The sign for minutes is " ′ "; for example, 15′.

The sign for seconds is " ″ "; for example, 25″.

The illustration 88°–20′–10″ means 88 degrees, 20 minutes, 10 seconds.

The Greenwich Royal Observatory is located in the eastern part of London on the Thames. From the meridian on which this observatory is located longitude is usually reckoned. For example, if it is 6 o'clock in the morning at a certain point on the earth when it is 12 o'clock at Greenwich there is a difference of 6 hours in time.

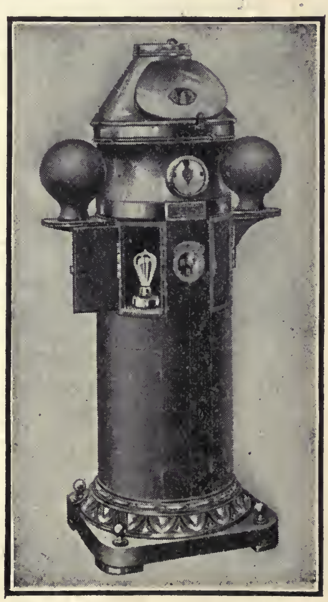


Fig. 346.—A ship's compass.

One hour corresponds to a difference of 15°. If a place has a difference in time of 6 hours from Greenwich, then there will be a difference of 90° in longitude.

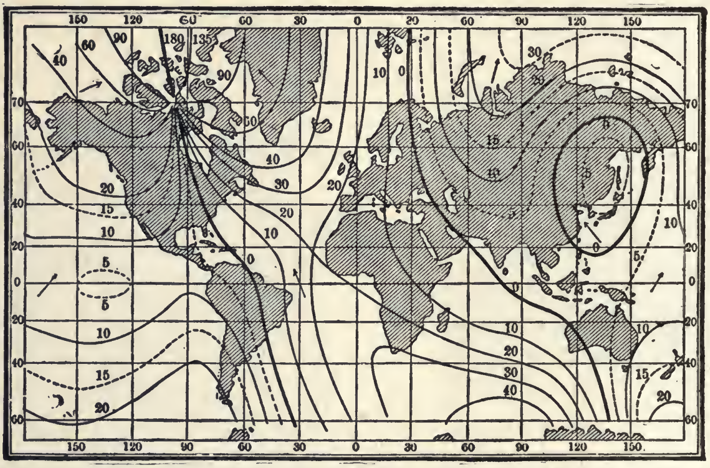


Fig. 347.—In what states of the United States does the compass point directly at the north pole? How many degrees must be allowed for New York City? For San Francisco?

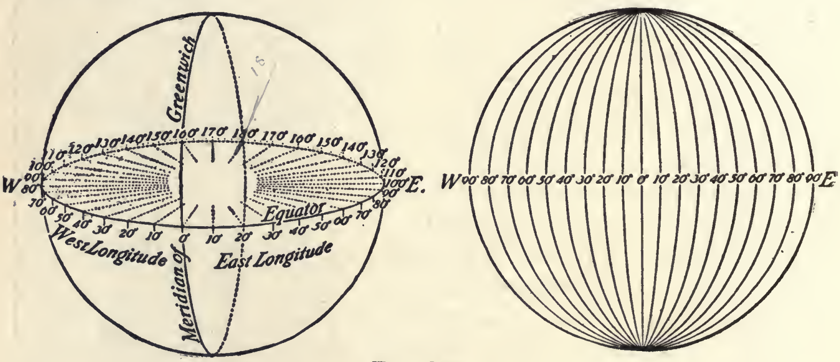


Fig. 348.

The difference in time between Greenwich time and that at your home is determined by a clock called a **chronometer.** Every ship carries one of these clocks which gives the time at Greenwich. By observing the sun through an instrument called a **sextant,** one is

able to determine the exact time of the day. By taking the difference between the time in Greenwich and this time they are able to determine the longitude of the place.

When the time by the sun is later than the time by the chronometer, the longitude is called **east longitude.** For example, if it is 10 o'clock A.M. at Greenwich and 11 o'clock A.M. at the spot where the ship is, the ship is 15° east longitude. If the ship records

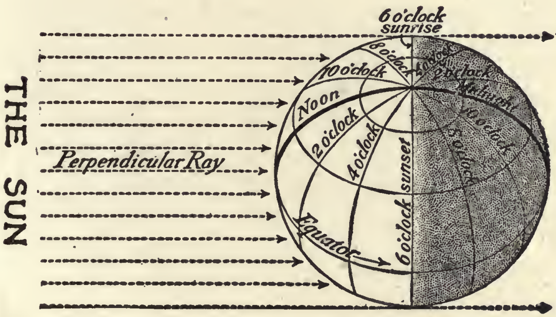


Fig. 349*a*.—The time on different meridians when it is noon on the prime meridian.

Fig. 349*b*.—International date line.

9 o'clock A.M., the ship is 15° **west longitude,** since the time is earlier than Greenwich time.

A Table of Longitude and Time:

360° of longitude corresponds to 24 hours of time.
15° of longitude corresponds to 1 hour of time.
1° of longitude corresponds to $\frac{1}{15}$ hour or 4 minutes of time.
15′ of longitude corresponds to 1 minute of time.
1′ of longitude corresponds to $\frac{1}{15}$ minute of time.
15″ of longitude corresponds to 1 second of time.
1″ of longitude corresponds to $\frac{1}{15}$ second of time.

International Date Line.—If you should start to travel west from Greenwich to go around the world, you would need to set your watch back one hour for every 15° of longitude passed over. By the time you had traveled around the world you would have set your watch back 24 times, or 24 hours. You would thus lose a whole day.

If you started eastward from Greenwich you would set your watch ahead 24 times, thus gaining a day in traveling around the world.

To overcome the difference of the extra day, all nations in 1884 agreed upon a place where the day should begin and end; or, in other words, where time should be read. This place is the 180th meridian east and west of Greenwich, and is called the **International Date Line.** This line does not follow the 180th meridian exactly, since it would cut some of the islands in the Pacific Ocean in two

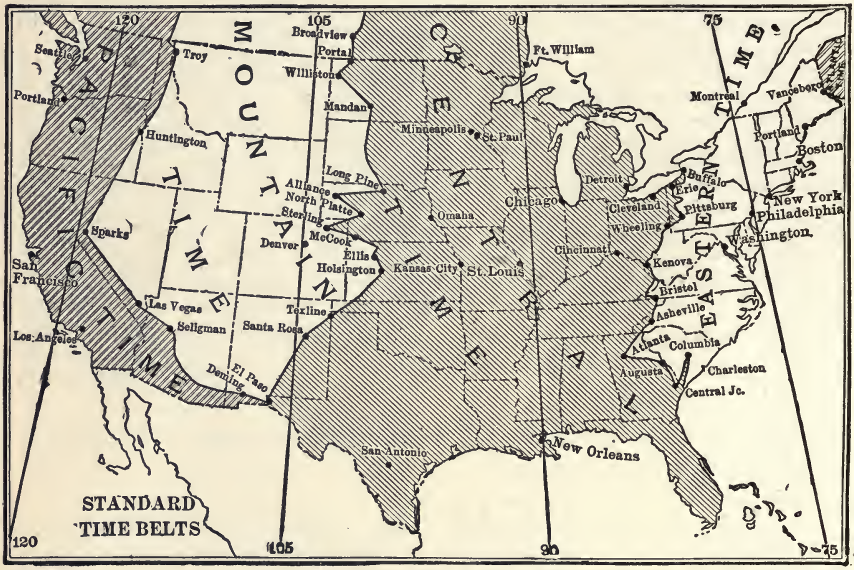


FIG. 350.

parts, making one day in one part while it was still the preceding or following day in the other part. If a man should cross this line on Monday, traveling west, he would call the day Tuesday. If he should cross this line on Monday traveling eastward, he must pass from Monday to Sunday.

Standard Time.—If you were riding in a train from New York to Buffalo the train, arriving at 1 o'clock by New York time, might leave Buffalo at 12.10; in other words, the time west of Buffalo is 1 hour behind the time at New York. If you were to travel across

the country until you reached North Platte, Nebraska, again your watch would need to be set back one hour. On arriving at Sparks, Nevada, another hour would be gained. From the time you leave

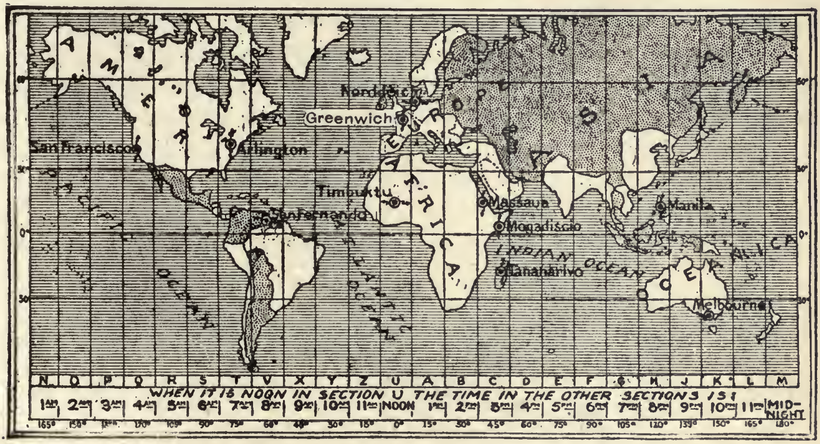


FIG. 351.—A map showing the proposed standard time belts of the world. We have seen how the distance traveled by a ship each day is found by comparing the local or ship's time with Greenwich time, the ship's time being determined by the position of the sun or stars and the Greenwich time by the vessel's chronometer. From this it will be noted that the difference east or west between any two places is merely the difference between the two local times expressed in degrees. No way has ever been found, however, for making a ship's chronometer keep exactly correct time. At times the clock's error is such as to render the accurate finding of the ship's position impossible; and in such cases, when the vessel is near land, disastrous results may follow. With the scheme of the International Conference the wireless signals will act as a check on the chronometers. The great importance of this may be realized when it is remembered that an error of one second in calculating the time at sea means an error, in determining the ship's position, of something like 1000 feet.

New York to your arrival in San Francisco, California, it would be necessary for you to set your watch back three hours.

This arrangement of time for our country is for convenience. When the sun is on the meridian of any town it is 12 o'clock noon,

and the time of all places east or west is earlier or later than noon. The same is true of every hour of the day for this place and other places east or west of it. This makes confusion in the arrangement of time tables, and in the running of trains. In some places this time is still used, and is called **sun time**; and the time by which the trains run is called **train time.**

Latitude.—Not only is it necessary for ships and people to know their distance east or west of the prime meridian, but also to know their distance north or south of the equator. For this reason the

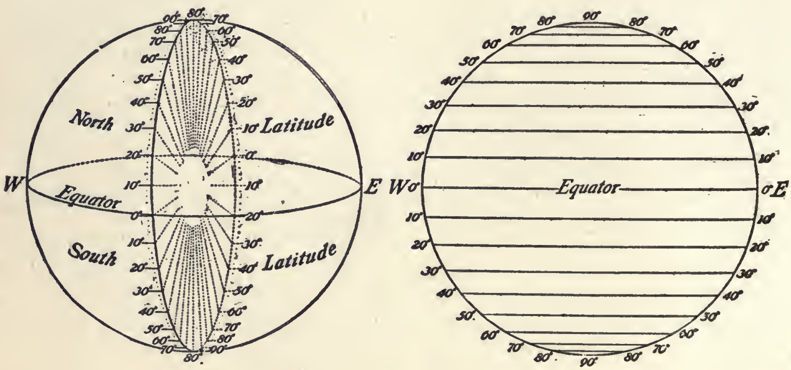


Fig. 352.—Degrees of latitude and parallels by means of which points are located on the earth as north or south of the equator.

earth has been divided into imaginary circles running around the earth parallel to the equator. The equator is an imaginary circle midway between the poles which is marked zero (0) **latitude.** The distance from the equator to the north pole is divided into 90°; likewise the distance from the equator to the south pole. A person in Maine, Ottawa, Canada, Michigan, Oregon, etc., is in 45° north latitude or one-half way to the north pole from the equator. A man in Central Illinois, near Springfield, is in 40° north latitude and 90° west longitude. At 9 o'clock in the morning in this place, it is 3 o'clock in the afternoon at Greenwich.

Questions

1. How can all places on the earth be located, east and west?

2. Chicago has a longitude of about 87° and 35′ West. What is the sun time of Chicago when a chronometer giving Greenwich time reads 11 o'clock P.M. What is the train time at Chicago?

3. What is the difference in time between the train time and the real sun time?

4. If a vessel is at 13° North latitude, 80° East longitude, and the sun time is 5 P.M., what time is it at Greenwich?

5. If it took you one hour to sail from the Aleutian Islands east of the 180th meridian to west of the 180th meridian, starting on Wednesday at 10 o'clock, what day and what hour would you arrive on the west side? Why?

6. What would be the difference in your answer if you were west of Baker Island and crossed the 180th meridian in the same length of time?

7. What causes the sun to seem to rise?

8. How would you determine the direction north if you were without a compass and the sun were not shining?

9. Why does not a compass in your town point directly at the north pole? Does it point east or west of the true north?

10. At what places in the United States would the compass point at the north pole and the north magnetic pole?

11. Which way does the compass point in Greenland?

12. In what direction does the compass point in Alaska?

13. Why is the bowl of a compass made of brass?

14. Why is the use of the north star a better method than the compass for obtaining direction?

15. Of what use would the compass be for an explorer who was going to the North Pole?

16. How does longitude assist in preventing train accidents?

17. What time is it at Greenwich now?

18. What day is it at Greenwich now?

19. What time is it in China?

20. What day is it in China?

21. What time and what day is it at the point of land in Siberia nearest to America?

22. If the sun does not shine for several days, why do sailors say they are reckoning longitude by dead reckoning?

23. If you travel from New York through San Francisco to Peking, China, how many times would you change your watch? Would you lose or gain time? How much?

24. Are there any places where you would change time from one day to another? Why?

25. Why was it necessary to have a place from which to reckon time?

26. Find two places less than 100 miles apart where the people in one place called the day Thursday and the people of the other place Wednesday?

27. What is the difference between sun time and standard time?

28. Why do we not reckon time by sun time?

29. How are we able to tell the correct time for any section of the country?

30. Why is latitude important?

31. What kind of climate would you expect to find in 30° north latitude, 60° north latitude and 10° north latitude?

HEAVENLY BODIES

Ancient Knowledge.—From time immemorial man has studied the universe. He has been interested in the stars, the moon and other heavenly bodies because they seem to have a certain element of mystery. The Chinese claim to have made many discoveries several thousand years B.C. Shepherds of olden times watched, studied and made records of things they saw in the heavens. The Greeks did much to classify knowledge which had been gained regarding the universe.

The Sun.—One of the heavenly bodies which is familiar to us is the sun which is about 91 to 93 millions of miles from the earth. The light given off from the sun is equal to that of 6000 wax candles at a distance 1 foot from the eye. It would require 600,000 full moons to produce a day as brilliant as a day produced by the sunlight. The sun is really blue. The sun, probably because of our atmosphere, has a tendency to appear red, since red rays pass

more readily through our atmosphere, while the blue rays are refracted.

Heat of the Sun.—It has been estimated that if the heat of the sun were produced through the burning of coal it would require about 8 trillion tons per second—enough coal to supply the entire world for many years. How the sun produces heat has been discussed on page 137.

Size of the Sun.—The volume of the sun is one million three hundred thousand times that of the earth and its weight about 198,000,000,000,000,000,000,000,000,000 pounds. So great is this weight that a man weighing 150 pounds on earth would weigh about 2 tons on the sun. Even his feet would weigh several hundred pounds.

Sun Spots.—Frequently, on the surface of the sun, dark spots may be seen to travel across its face and disappear on the other side. This movement takes place because the sun also rotates on its axis.

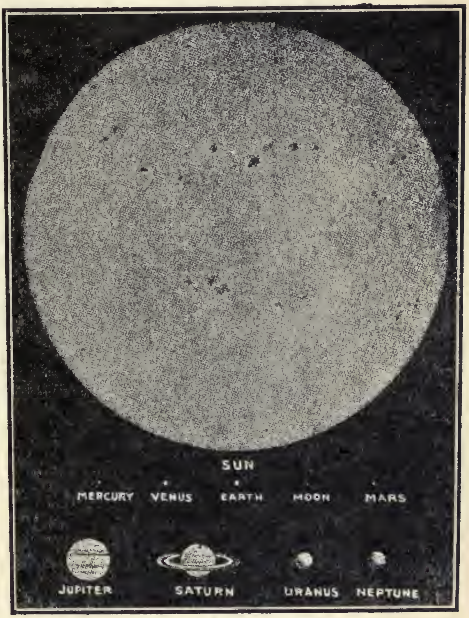


Fig. 353.—Relative sizes of the planets and the sun.

Sun-spots appear to be dark, but in reality they are intensely bright—far brighter than any terrestrial source of light. They are uprushes of metallic vapors in which vanadium, titanium, and iron are very evident, together with many of the common metals. They are immense vortices, like the waterspouts seen at sea, with the trumpet-shaped part at the top. As these immense vortices whirl, the vapors of the heavier metals are carried from below outwards, and are cooled sufficiently to produce oxides which fall back

again into the great heated mass of material of which the sun is composed. The cooling of these oxides makes them appear dark.

The Moon.—The next body of interest to us in the sky is the moon. Many superstitions and erroneous beliefs have come down to us regarding the moon. Some people have believed that the moon controls the weather; this, of course, is absurd. The moon is about 239,000 miles from the earth. The moon, unlike our earth, turns on its axis once in $27\frac{1}{2}$ days, which means that daylight on the moon is as long as 14 of our days, and that a night is of equal duration.

FIG. 353*a*.—Mountainous surface of the moon.

When the moon comes up above the horizon it appears to be considerably larger than later in the evening. There are two reasons for this:

1. We are looking through a greater amount of atmosphere. This magnifies the size of the moon.

2. We are comparing the size of the moon with objects on the horizon.

After it has risen in the sky there is nothing with which to make comparison.

No one has ever seen the other side of the moon since it revolves around the earth with the same side toward us. The ancients early noticed that the moon did not rise at the same time every night, and at certain times did not appear during the night at all but during the day. They observed that the moon rose 1 hour later (53 minutes) each night.

The light of the full moon is only about $\frac{1}{600000}$ that of the sun.

During the day on the moon the temperature must rise to a tremendous height, while at night it drops far below zero.

Dry and Wet Moon.—When a line joining points or horns (cusps) of the moon lies nearly parallel to the horizon the moon is called

Fig. 354.—Different phases of the moon.

the " dry " moon, since it will hold water. When the line connecting the points or horns (cusps) of the moon is perpendicular to the horizon, it is called a " wet " moon.

The direction of the form of the crescent has nothing to do with

the weather. The direction in which the cusps of the moon point depends upon the position of the sun, since the horns must point away from the sun. On the moon there is no twilight because there is no air. The sky is black and covered with stars, even at midday. There are no gorgeous colors of the heavens at sunrise or sunset, for the sun rises instantly into day, and after two of our weeks goes down. Night falls at once.

The Man in the Moon.—The moon appears to be dotted here and there with great volcanic craters and mountains. When the sun strikes one of these mountains obliquely a shadow is distinctly seen, causing the appearance of the "Man in the moon" or the "Lady in the moon." All these craters and mountains have been named after distinguished men in science. Copernicus is the largest volcanic crater. It is situated on the top of the nose of the man in the moon. Its diameter is 46 miles.

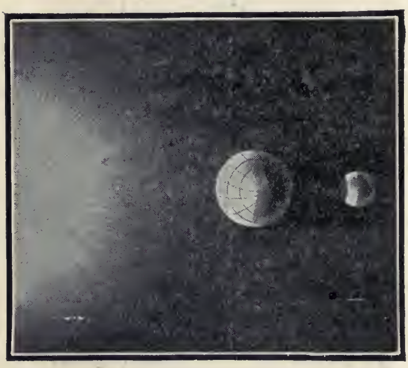


FIG. 355.—Eclipse of the moon.

Tides.—Twice a day, about 12 hours and 25 minutes apart, the water of the ocean begins to move toward the shore. This motion continues for about 6 hours, and is called **flood tide.** For the next 6 hours the water flows back in the motion known as **ebb tide.** The tides are caused by the moon pulling the water on the surface of the earth. Since the water is free to move, it follows the sun and the moon about, as the earth rotates on its axis. If the sun and the moon are on the same side of the earth, we have very high tides on the side of the earth toward the sun and the moon and on the side of the earth directly opposite, since the sun and moon are pulling the water away from the earth. If the sun and moon are on opposite sides of the earth we also have very high tides. When the sun and moon are on the same side, it is said that they are in **conjunction**; on opposite sides, in **opposition.** When the sun and moon are in conjunction or opposition, the tides are called **spring**

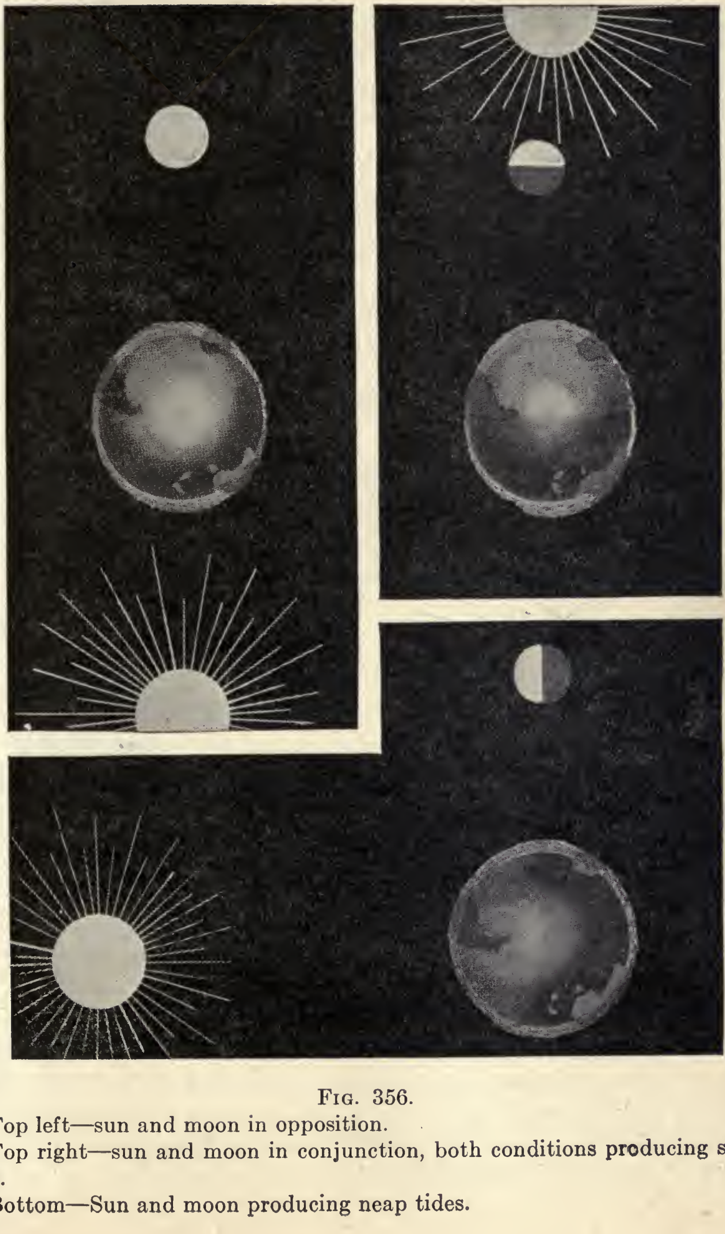


FIG. 356.

Top left—sun and moon in opposition.

Top right—sun and moon in conjunction, both conditions producing spring tides.

Bottom—Sun and moon producing neap tides.

tides, but when the sun and moon are pulling at right angles, the tides are called **neap** tides. The moon pulls the water with greater force than the sun because the moon is 400 times nearer the earth than the sun.

The Earth.—The earth is one of the small planets, and, because of its rapid motion when it was in a molten mass, it became flattened at the north and south poles. Such a body is called an **oblate spheroid.** The diameter of the earth from pole to pole is 26 miles shorter than through the earth at the equator. The earth's diameter is about 8000 miles and its circumference 25,000 miles. The curvature of the earth amounts to about 8 inches per mile. The amount

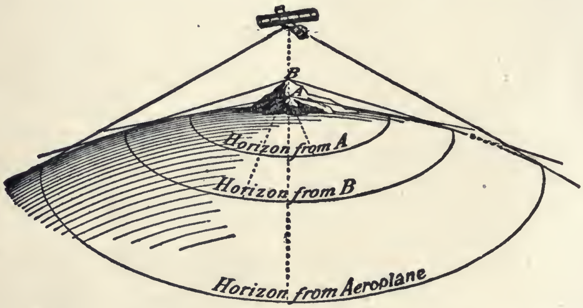


FIG. 357.—The broadening horizon seen from different elevations.

of curvature increases as the square of the distance multiplied by eight. For example, for 2 miles the curvature of the earth would be $2^2 \times 8$ in. equals 32 in.; for 3 miles, $3^2 \times 8$ in. equals 72 in.; for 4 miles, $4^2 \times 8$ in. equals 128 in., etc.

The earth turns on its axis once in 24 hours; however, we all know that day and night are not of the same length at all times of the year. The difference in the length of the day is caused by the inclination of the axis of the earth.

The north pole has a night lasting about six months, and a day equally long, as will be seen by one of the diagrams. The earth travels around the sun in an orbit once every year of $365\frac{1}{4}$ days. Because of this extra fourth of a day it is necessary to add one day to every fourth year. We call this year a leap year. The true length of the year is 365 days, 5 hours, 48 minutes and 46 seconds.

Adding the one day to every four years makes the average length of a year 365 days and 6 hours. This makes the year 11 minutes and 14 seconds too long, which amounts to over 3 days in 400 years. The year at the beginning of every century is not a

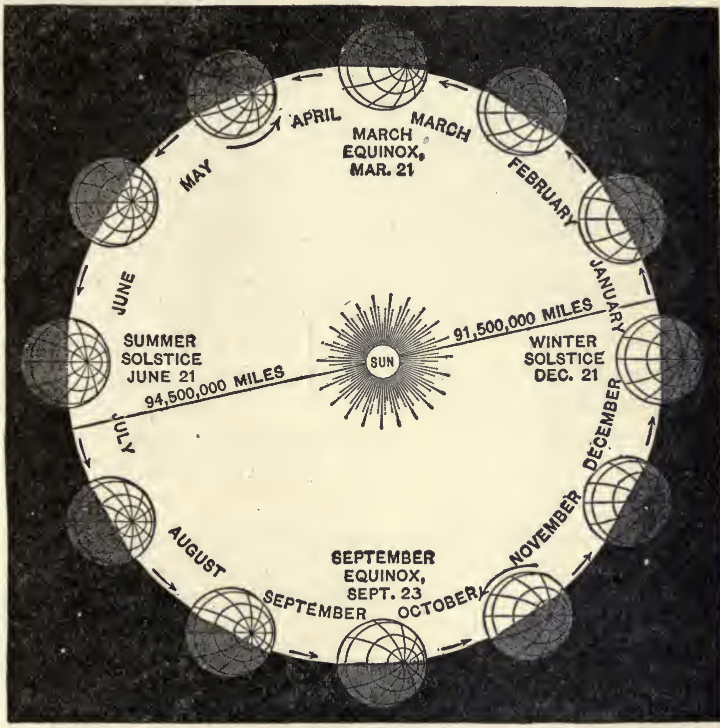


FIG. 358.—Position of the earth in its orbit each month. What does solstice mean? What does equinox mean? Why is December 21st called the winter solstice? June 21st the summer solstice? March 21st and September 23rd the equinoxes?

leap year unless it is divisible by 400—an arrangement which corrects the discrepancy.

Meteors.—On some starry night you may have seen a **meteor** dart across the sky. Some people call these "falling stars" or

"shooting stars." They are small solid bodies, sometimes so small as to weigh only a fraction of an ounce. They are moving at a tremendous rate of speed, which causes a great deal of friction when they come within the atmosphere of the earth. They then become very hot and usually burn up, just as a rifle bullet in passing through the air gets very hot. Sometimes, however, they are very large, and when they fall to the earth they are found to weigh tons. They may be small bodies which are in space and are drawn toward the earth by the power of gravitation. Some scientists have accounted for them as having been shot out by the sun or thrown into space by volcanoes on the surface of the moon.

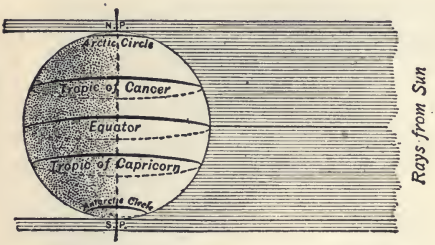


FIG. 359.—The position of the earth at the equinox.

The small meteors or shooting stars are supposed to be tiny pieces of matter which once belonged to a comet. As the earth travels on through space it sometimes crosses the path where there are pieces of an old worn-out comet. At such times a great many shooting stars are seen in the heavens. Hundreds of these pieces are entering our atmosphere and are burned up before they reach the earth. Until a meteor gets within about 160,000 miles of the earth, it is attracted by the sun more than by the earth.

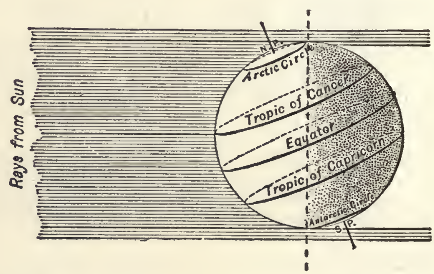


FIG. 360.—Position of earth at summer solstice.

Origin of the Solar System.—It is believed that millions of years ago all the bodies we know about in the solar system existed as one great cloud called a **Nebula.** This enormous cloud of heated vapor began to cool and, growing smaller, took on a rotary or spin-

ning motion like that of a top. As this speed increased portions of this vapor were thrown off, as water is thrown off a grindstone, or mud from an automobile tire. These rings of vapor which were thrown off also started cooling and, retaining their whirling motion, formed the earth and planets. They in turn threw off vapor because of their speed, forming their moons (satellites). The great planet

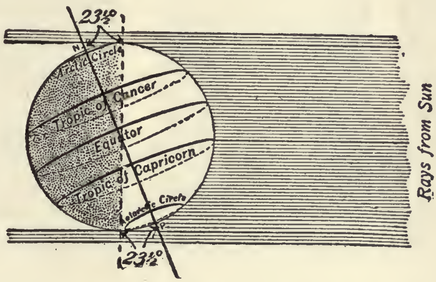


FIG. 361—The position of the earth at the winter solstice. What part of the earth has continuous day? Night? Where would the day be longer than the night? Night longer than the day? Why? Where would the sun just "set" and begin rising again?

Saturn is still very hot and is throwing off rings of vapor which may some day become moons.

The earth cooled off slowly until animal and plant life could live upon it.

In the diagram you will see the effect of heating and cooling an apple. The earth's surface may be compared with that of the apple. As it cooled off, many irregularities were formed which produced continents and oceans, hills and valleys, mountains and plains.

Mercury.—Mercury is so near the sun that it is almost impossible to observe it carefully. One side of the planet has perpetual day and the other perpetual night, which means that one side must be intensely heated, while the other side maintains a very low temperature.

Venus.—This planet is surrounded by clouds on which the sun shines with the effect of giving Venus a very beautiful appearance.

It is the brightest planet because the reflecting power of the surface so great. When seen close to the sun at sunset it is called the "Evening Star," and when it appears in the east at sunrise it is called the "Morning Star."

The head of a comet.

The comet of 1918

The effects of heating and cooling an apple.

Fig. 362.

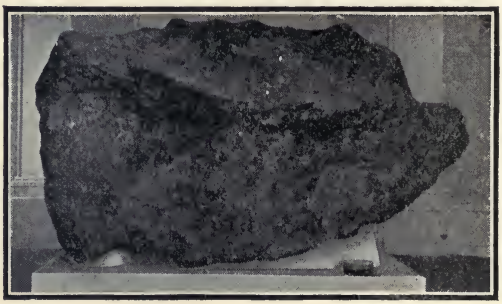


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Fig. 363.—The Cape York meteorite which weighs 36.5 tons.

Mars.—Mars sometimes appears in the sky reddish in color. Because of this appearance, the planet has received the name of the Roman war god, Mars. Mars is very interesting to us because the planet is much like our own. It is possible that people live on this planet. The day is about the length of ours. It has a north pole

and a south pole on which snow appears during the different seasons of the year. There are two moons, one of which travels so fast that it goes around Mars three times a day. The planet is surrounded with a blanket of air probably much thinner than our own. Mars is covered over with a network of long, dark, thin lines called **canals.** It is believed that these canals are caused by water and vegetation growing on the surface of Mars, as the red appearance of the planet is supposed to be due to great stretches of desert land.

Jupiter.—Jupiter is the largest of all the planets. It is more than 1300 times larger than our earth. Jupiter has eight moons, four

FIG. 364.—The planet Jupiter. The ringed planet Saturn.

small ones and four large ones. The four large ones may be seen with a small telescope.

Saturn.—Saturn is one of the most beautiful planets in the heavens. It is surrounded by three rings of gaseous vapor of which the middle and broadest one is probably about 10,000 miles wide. The planet changes position so that the rings may be seen more easily at certain times.

Uranus and Neptune.—Further out in space is the planet Uranus which has four moons. Beyond Uranus lies the planet Neptune with only one moon. Neptune is almost in utter darkness, for it is so far from the sun it receives little of its light.

The Small Planets. (Asteroids.) Beyond Mars there are a number of very tiny planets, so small that the diameter of the

INFORMATION ABOUT

Planet: In Order According to Distance from Sun.	Distance from Sun, Miles. Average.	Distance from Earth, Miles.	Time Required to Reach it Traveling on Express Train 1 mile per minute. Years.	Size Compared with Earth.	Surface Compared with Earth.	Density.
Mercury .	36,000,000	48,500,000 to 137,500,000	110	$\frac{1}{20}$	$\frac{14}{100}$	3.70
Venus....	62,200,000	25,000,000 nearest distance	50	$\frac{1}{9}$	$\frac{93}{100}$	4.89
Earth.....	92,900,000	0		1	1	5.53
Mars.....	141,500,000	34,000,000 nearest distance	76	$\frac{1}{7}$	$\frac{28}{100}$	3.95
Jupiter...	483,300,000	390,000,000 average	740	1264	116.9	1.33
Saturn...	886,000,000	793,000,000 nearest distance	1470	759	83.3	0.72
Uranus...	1,781,900,000	1,688,900,000	3160	63	15.9	1.22
Neptune .	2,791,600,000	27,000,000,000	5055	82	18.9	1.11

OUR PLANETS

Light and Heat Compared with Amount Reaching Earth.	Year, Length.	Day, Length.	Rotation On Axis.	Speed In space.	Moons, Number.	Weight of One Pound.	Atmosphere.
6.8	88 days or $\frac{24}{100}$ year	Perpetual day and night	Once during journey about sun	1773 miles per min.		$5\frac{1}{2}$ oz.	No.
1.9	$7\frac{1}{2}$ mo. or $\frac{62}{100}$ year	Ditto	Ditto	1296 miles per min.	None	13 oz.	Dense & cloudless
1	12 mos.	24 hrs.	17 miles per min.	1102.8 miles per min.	One	16 oz.	Yes
$\frac{1}{2}$	1.88 year	24 hrs. 37 min. 22.7 sec.	9 miles per min.	900 miles per min.	Two	6 oz.	Yes
$\frac{1}{27}$	11.86 years	9 hours 55 min.	473 miles per min.	483.6 miles per min.	Eight	42 oz.	Very dense.
$\frac{1}{100}$	29.46 years	$10\frac{1}{4}$ hours		366 miles per min.	Ten	$18\frac{1}{2}$ oz.	Very dense.
$\frac{1}{368}$	84.02 years	about 10 or 12 hours		252 miles per min.	Four	$10\frac{1}{2}$ oz.	Very dense.
$\frac{1}{900}$	164.78 years	19 hours		$201\frac{3}{5}$ miles per min.	One	$14\frac{2}{5}$ oz.	Very dense.

largest is only about 500 miles, and some of them so small that a person would be able to ride around one in a few minutes in an automobile. A farmer would need the entire planet for his garden.

The pull of gravity on some of these is so slight that a man could leap 60 feet and descend upon the planet without sustaining any injury. These planets collectively are called **asteroids.**

Stars.—All the stars are much like our own sun. Each twinkling star may have a system of worlds or planets traveling around it. It is possible that some of the worlds are inhabited and that our sun is seen shining only as a small star in the far distant unknown.

The stars seem to be too numerous to count but in reality only about 3000 stars are visible to the naked eye. With the aid of a powerful telescope the number of stars seen increases to many millions.

How the Distance to the Stars is Measured.—The distance to the stars is measured in a very interesting way: Let us look at some object a short distance from us and then move in a straight line to some other spot and look at the same object again. Draw a line from the first position to the object and another one from the second position to the object, forming an angle. Return to the first position and look at some object farther away than the first one. Move to the second position and view the same object. We find the new angle formed to be much smaller than the first angle. We learn that the farther the object is from us the smaller the angle becomes.

The basis for the calculation of the distance of stars is measured much in the same way except that two positions of the earth are chosen from which to observe a star. The distance is the mean radius of the earth's orbit (the earth's distance from the sun). This distance serves as a base line and can be used to view the angular displacement of stars viewed just as a surveyor may use a base line to measure the angle displacement of objects on the earth. In the case of the stars this displacement is called the **parallax.** Stars are not listed according to distance, but according to their parallax. For example, Alpha Centaura, probably the nearest star except our sun, is at a distance of about 25,000,000,000,000 miles. To find the distance of any star from the earth we divide 19,000,000,000,000, the mile value of one second, by a fraction representing the actual parallax. For example, the North Star has a parallax

of 0″.06. Dividing 19,000,000,000,000 by 0″.06 we get about 316,666,666,000,000 miles.

Below is a list of parallaxes of the most important stars. Work some of them out and determine their distance from us. Those which have all zeros signify that the distance is so great that no angle can be obtained.

Polaris (the north Star), 0″.06; Aldebaran, 0″.11; Capella, 0″.09; Rigen, 0″.00; Betelgeuse, 0″.02; Canopus, 0″.00; Sirius, 0″.37; Castor, 0″.20; Pollux, 0″.06; Procyon, 0″.30; Regulus, 0″.02; Arcturus, 0″.03; Alpha Centauri, 0″.75; Antares, 0″.02; Vega, 0″.11; Altair, 0″.23; Deneb, 0″.00; Fomalhaut, 0″.13.

The figure 19,000,000,000,000 is obtained by multiplying 93,000,000,~~000,~~ the radius of the earth's orbit, by 206,265, the distance from us of an object having one second of arc as its parallax. The number equals 19,172,645,000,000, but for convenience just 19,000,000,000,000 is chosen as an adopted standard of measurement for the distance of stars. The name applied to this number is the "parsec."

Comets.—Comets occasionally visit the solar system. The comet usually has a long tail millions of miles in length. The comet and tail are supposed to be made up of little particles covered with luminous gas. The particles are composed of carbon, sodium, iron and magnesium. Occasionally the comet breaks up and the fragments continue on their way as meteors. Sometimes the earth plunges through a swarm of meteors. At such a time the sky seems to be full of shooting stars, so called.

Comets pass into space and sometimes return a great many years afterwards. Others go near the sun and after passing very close to it rush off into space probably never to return. These strangers of space are very interesting. In olden times people thought that they foretold war, famine and many other sufferings.

Constellations.—None of us can look at the heavens on a clear night without being overwhelmed by an almost endless vista of suns beyond suns and systems upon systems. The mind of the ancients could not grasp the vastness of the great universe. In a childlike way they traced the outlines of men and beasts among the stars and invented a pleasing story about each. The groups of stars in these imaginary pictures are called constellations.

Movement of Stars.—The stars seem always to be in the same place, but in reality they are moving through space. Some of the stars are traveling at enormous rates of speed, but they are so far away that it would require years to detect any movement even if any star should move one million miles per day. Our own star, the sun, is moving at the rate of about 800 miles per minute. Scientists believe that stars are all moving around some great center or centers.

Nebulae.—It is believed stars were made from vast gaseous bodies called nebulae (meaning cloud). Nebulae are scattered throughout the sky as masses of misty light moving through space like stars. They are made up of glowing gases. Many of them are spiral or disc shaped.

A nebula is a star in the process of forming. Only two or three nebulae can be detected without a telescope. A blur of light surrounding the third star of Orion's sword is one of the nebulae which may be observed with the naked eye. It is estimated that some of the nebulae are so far away as to require 8,000,000 years for their light to reach us.

Age of the Star.—The color of the stars tells us something as to the age of a star. When they are young stars, they are composed of thin gas and shine with a blue or white light. The star Rigel (re-gel), below the belt of Orion, is a white star.

The older the stars grow, the more solid they become, and the more their light resembles that of the sun. As they grow older, they also become red and more condensed. Betelgeuse in the constellation of Orion is an example of a red sun. The colors of the stars vary. Brilliant white, violet, blue, green, yellow, orange, fiery red and red are some of the colors of the important stars.

When the stars become very old they lose all color and heat. There are many such stars, each representing a sun which has become cold and desolate.

Size of Stars.—The stars vary in size. It is possible we do not see the largest suns in the universe. **Canopus** (ca-no′-pŭs) is believed to be larger and greater than Sirius (sĭr′-ĭ-ŭs). This star is in the southern hemisphere, and looks only about half as bright as Sirius. Canopus' distance from us is so unthinkably immense, and its size so far beyond our estimate, we cannot begin to realize the wonder of this huge sun.

Constellations and Important Stars. Ursa (ûr′-sȧ) **Major and Ursa Minor,** the Big Bear and Little Bear (Big Dipper and Little Dipper),

get their names from an ancient story of a beautiful mother called Callisto (kă-lĭs′-tō), Juno's maid, who had a little son named Arcus (är′-kŭs).

Juno was very angry because of Callisto's beauty, and so she changed her into a bear. When Arcus grew up he became a hunter and was about to kill his mother

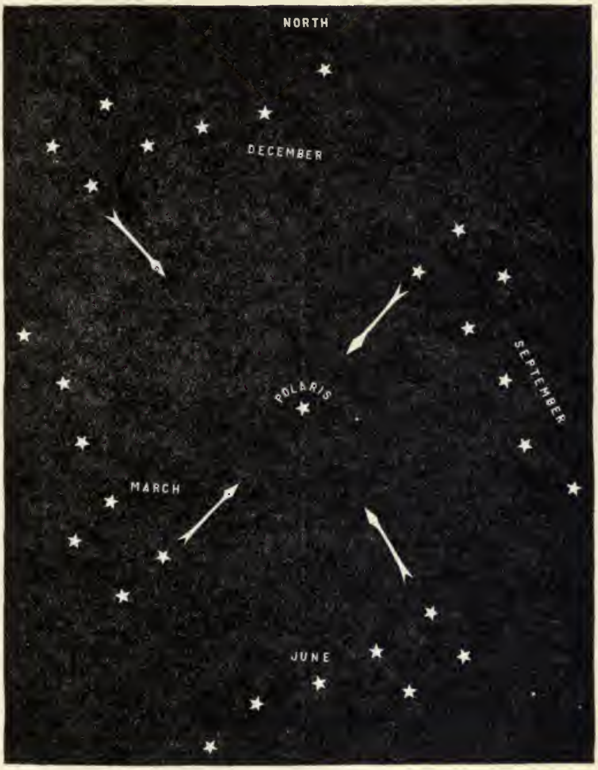

FIG. 365.—Position of the Big Dipper at different times of the year. The position also changes during 24 hours.

when Juno, realizing the danger, put them both in the heavens as stars and caused them to keep moving around and around, instead of rising and setting like other stars.

Polaris (Pō-lā′-rĭs), the **North Star,** is the most important star in the constellation of Ursa Minor. It is the last star in the handle of the

Little Dipper. A line drawn through the last two stars in the end of the Big Dipper, from the bottom to the top, and extended will pass through Polaris. Fig. 367. The star receives its name from the fact that the earth's orbit points at it. The distance to the Pole Star is so great that it requires about forty-six years for the light to come to us.

Draco is represented by a figure of a long serpent stretching between Ursa Major and Ursa Minor.

Cassiopeia (kăs'ĭ-ō-pē'yȧ) is represented as a queen seated on her throne. On her right is her husband, King Cepheus (sē'fūs).

Juno and Jupiter became very angry at Cassiopeia because of her boast that she and her daughter Andromeda (ăn-drŏm'-ė-dȧ) were more beautiful than any of the goddesses, and placed the whole family in the sky. *The queen's chair is composed of five brilliant stars that form a W.* Neptune was also very indignant over Cassiopeia's boast, and sent a sea monster, Cetus, to destroy the coast of Ethiopia. King Cepheus was forced to bind his daughter to a rock to be devoured by Cetus (sē'-tŭs), but Perseus (pêr'-sūs) slew the terrible monster. Perseus will be seen holding a sword in his right hand, while in his left hand is the head of Medusa.

Perseus (the son of Jupiter) is supposed to have beheaded Medusa, whose hair was hissing serpents, and whose features were so hideous as to change into stone every living object upon which she fixed her gaze.

Aries (ā'rĭ-ēz), the ram, bore a golden fleece. Mercury provided this ram for Phrixus (frĭx'-sŭs) and Helle to escape from Ino (ī'nō), their stepmother. When the ram started for the heavens Helle became dizzy and fell off into the sea, afterwards called Hellespont, now the Dardanelles. The other child Phrixus offered the ram in sacrifice to Jupiter and gave the golden fleece to his protector. Jason tried to find the golden fleece afterwards.

Taurus is represented as a bull in the act of plunging at Orion.

Aldebaran (al-deb'-a-ran) is the end star on the lower arm of the V-shaped collection of stars called the **Hyades.** It is the red eye of the angry bull, Taurus. This sun gives off 45 times as much light as our sun, and the light requires 32 years to reach us.

The Pleiades (ple'-ya-dees), another part of the constellation of Taurus, were the daughters of Atlas. They prayed to the gods for protection from Orion the hunter. Jupiter placed them in the sky. Seven stars may be seen in this group. There are in reality over three thousand. The stars are surrounded by a misty appearance which makes astronomers believe they form a great star system, evolving from the

nebula. The stars look close together, but in reality they are very far apart. It would require several years for light to travel from one star to another and hundreds of years for the light to reach us.

NORTHERN HEMISPHERE.

FIG. 366*a*.

Pegasus (Pĕg′á-sŭs), the flying horse, contains the **Great Square of Pegasus.** The stars at each corner of the square are bright but not large. There are no noticeable stars within the square.

Pegasus was supposed to have sprung from the body of Medusa after her death.

Auriga (ô-rī′-gȧ), the charioteer or wagoner, is a constellation the origin of whose name which is unknown. **Capella** (kȧ-pĕl′-ȧ), bright as a diamond, is the principal star in this constellation. It is high

SOUTHERN HEMISPHERE.

FIG. 366*b*.

above Orion toward the north, about half way between Orion and Polaris. It has no rival near it. Capella resembles our sun although it is very much larger. It gives off 120 times as much light and about

forty years is required for this light to reach us. This star is almost in the zenith during January and February.

Cetus, the whale, is a huge sea monster.

Pisces (pĭs′ēz), the fish, is represented by two fish tied together.

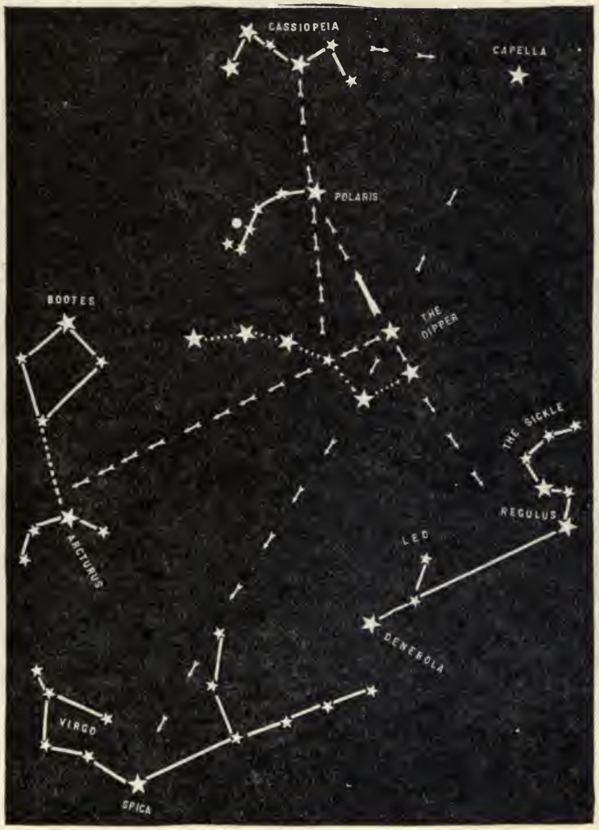

FIG. 367.—The Dipper as an index to the stars.

This constellation consists of small stars, and cannot be seen unless the moon is absent.

Gemini (jĕm′ĭ-nī), the twins, represent twin brothers, **Castor** and **Pollux**.

These two young men were very skilled in training horses and boxing. They accompanied Jason in his search for the golden fleece. Castor was slain which caused Pollux so much grief that Jupiter placed them in the heavens as immortals. These stars, Castor and Pollux (pŏl′ŭks), were supposed to exert a benign influence on the ocean; therefore, they were loved by sailors.

The two stars may be easily seen during the winter months almost in the zenith, in a part of the sky where there are no other bright stars. Pollux is a yellow star and about the age of our sun, while Castor is white and a young star.

Orion is represented as a hunter attacking Taurus, the bull.

Orion was bitten in the heel by Scorpion, because of his boast that he could conquer any animal. Diana placed him among the stars. Sirius and Procyon (prō′sĭ-ŏn), his dogs, are following him. The Pleiades are flying before him.

Below Orion's belt is **Rigel,** a bluish white star, a sun blazing with the fires of youth. Rigel is a young sun. This star is so far away we cannot measure the distance.

Above the Orion's belt is the beautiful red star **Betelgeuse** (bet-el-guz). It is a very old star, and is growing cold as the color shows. This star will soon be an extinct sun. It is so far away from us that the distance has not been measured with certainty.

Canis Major (Great Dog), and **Canis Minor** (Little Dog) contain each a brilliant star, **Sirius,** the dog star, and **Procyon** (prō′-sĭ-ŏn) the little dog star.

Sirius is the most brilliant of all the stars in the sky. It is ever changing to blue, rosy and white. It is a young star about twenty times the size of our sun. The light from this sun reaches us years after it starts, as the distance from us is at least 50,000,000,000,000 and possibly more than 100,000,000,000,000 miles. The brilliancy of this star is estimated to be from 72 to 228 times as great as that of our sun.

Procyon is a white star which gives out about eight times as much light as our sun, and the light requires about ten years to reach us.

Leo, the lion. This constellation has its principal stars arranged in the form of a sickle. At the end of the handle of the sickle is the glittering white star **Regulus** (rĕg′-u-lŭs). This is a great sun, giving out 1000 times as much light as our sun. It takes about 160 years for the light to reach us from this giant of the heavens.

Cancer is the crab. In this constellation is a luminous spot called the **Beehive.** An ordinary glass will cause this spot to resolve into stars.

FIG. 368.—The Stars during the winter months.

Virgo (vŭr′gō), the virgin, is a beautiful maiden with folded wings. **Spica** (spī′kȧ) is the principal star. This star is used for determining longitude at sea. It is so far away that the distance has never been measured.

Hydra is represented by a long straggling serpent. To kill this serpent was one of the twelve labors of Hercules.

Canes Venatici (vė-nā′tĭ-cĭ) represent hunting dogs.

Fig. 369.—The Stars during the summer months.

Berenice's (Bĕr′ē-nī′-sēz) **Hair**, a beautiful cluster of stars. Berenice was the wife of Ptolemy (tŏl-ē-mĭ), who was sent on a dangerous mission. Berenice consecrated her beautiful tresses to Venus for the safe return of her husband.

Boötes (the bear driver) is represented as a huntsman grasping a club in his right hand, while with his left he holds by a leash his two greyhounds. Boötes is supposed to have been Arcus.

Arcturus (ark-tū′-rŭs) is a beautiful bright star in this constellation. The light given off by this sun is equal to a thousand times that of our sun. Its light reaches us in about 160 years, and it has a diameter of several million miles. In fact this is one of the largest of the suns. It is traveling nearly five miles a second toward the earth. During June and July Arcturus is almost overhead in the early evening.

Hercules, the great warrior, holds a club in his right hand.

Corona Borealis (bō′rė-ā′-lĭs), the northern crown, consists of six stars arranged in a semi-circular form.

Serpentarius (sŭr′pĕn-tā′rĭ-ŭs), or **Ophiuchus** (ŏf′ĭ-ū′kŭs), is the serpent bearer.

Libra represents the goddess of justice. The constellation may be recognized by the four-sided figure formed by the principal stars.

Scorpio is a huge scorpion.

Scorpio sprang from the ground at the call of Juno to sting Orion.

Antares (an-ta′-rees), the principal star of Scorpio, is a fiery red star around which revolves a bright green star. It can best be seen about ten o'clock in the evening during June and July.

Sagittarius (săj-ĭ-tā′-rĭ-ŭs), the archer, holds a bent bow as if ready to let an arrow fly at Scorpio.

The **Southern Fish** has one important star, **Formalhaut,** far down in the south. This star is in the mouth of the fish, of a slight reddish tint, and has no rival in the southern sky. It is used by sailors for navigation.

Cygnus (cyg′nŭs), the swan, is a group of stars forming the large and beautiful Northern Cross. **Deneb** (den′eb), or **Arided** (ȧ′-rĭ-dĕd′), is in this constellation. It is a very large sun, white in color. It has been estimated it would require 325 years for light to come from this star.

Lyra, the harp, contains one brilliant blue star Vega (vee-ga), the brightest summer star. It is a very large sun, giving off ninety times as much light as our sun. Light travels to us from Vega in twenty-

nine years. Our whole solar system is moving toward this sun at the rate of thirteen miles per second.

This is the harp upon which Orpheus produced such wonderful music as to cause wild beasts to forget their fierceness, rivers to cease flowing, and the rocks and trees to stand entranced.

Aquila, the Eagle, contains a great sun called **Altair** (ăl-tä′-ĭr) which gives off nearly ten times as much light as our sun. Light from this star reaches us in fifteen years. Northeast of Altair is a diamond-shaped cluster of stars called the **Dolphin.** It is also called **Job's Coffin.**

A moment but to reflect,
  Produces a feeling of wonder and awe:
All things in the Universe,
  Move according to some Divine Law.
Some Force behind it all,
  A Master Force it would seem,
Creates order in the vast unknown,
  And over all reigns supreme.

Questions

1. At your age how many years old would you be if you were living on Mercury, on Venus, on Jupiter, on Neptune?
2. How many miles an hour is the earth traveling in space?
3. How fast is a building moving with the surface of the earth as the earth rotates?
4. How much faster would a building move on Jupiter?
5. How much would you weigh on Mars, on Jupiter on Venus?
6. How many hours further away from the sun is Neptune than the earth?
7. If Columbus, when he discovered America, could have started to visit the planets on an express train going at the rate of a mile a minute, what planets would he have stopped at and in what year? Near what planet would he be now?
8. If you are able to lift 100 pounds on earth, how many pounds would you be able to lift on Mars?
9. What planets would Julius Cæsar have visited and what planet would he now be near, if he had started 50 B.C. at the above rate?

10. How many planets the size of Mercury would be required to make a planet as large as the earth?

11. How many earths would be required to make a planet as large as Jupiter?

12. What planet has a specific gravity equal to about that of gasoline?

13. What planet has a specific gravity nearest to the specific gravity of cider vinegar, or maple syrup?

14. What planet compares with glycerine; what one with diamond, in specific gravity?

15. How long would it take you to cross the ocean if you could travel as fast as Mercury travels through space?

16. If you can jump 3 feet on the earth, how high a fence would you be able to jump on Mars?

17. Why does not the sun burn up?

18. Why does the sun make bodies weigh a great deal more than they do on the earth?

19. How much would you weigh on the sun?

20. How does the sun get its heat?

21. What are some of the superstitions regarding the moon?

22. How can you tell a new moon from an old moon?

23. Why do we have a half moon?

24. What is meant by a full moon?

25. Which way do the horns of a new moon point, up or down, east or west?

26. How can you tell by the horns when the moon is an old moon?

27. What causes the " man " in the moon?

28. Why does the moon have such a tremendous effect on our tides?

29. Why do we have higher tides during certain times of the year than at others?

30. If the water in a pan is made to whirl rapidly why is the central portion lower than the edge of the water?

31. Why is the earth flattened at the poles?

32. Why is it necessary to have leap years?

33. Why do more meteors appear at certain times of the year than at others?

34. Why does a meteor leave a streak of light after it?
35. Why do some meteors strike the earth?
36. Why did the earth become irregular in shape while cooling off?
37. On what planet would you live in continual twilight?
38. Why do some people believe that Mars is inhabited?

CHAPTER XIV

MACHINES AND WORK

AGE OF MACHINERY

In the early days man did all his work by hand. The savage learned to do work with a simple machine, such as a crooked stick. From such a simple device as this man has gradually built up wonderful machines to save labor and to produce many manufactured

Levers of the First Class:

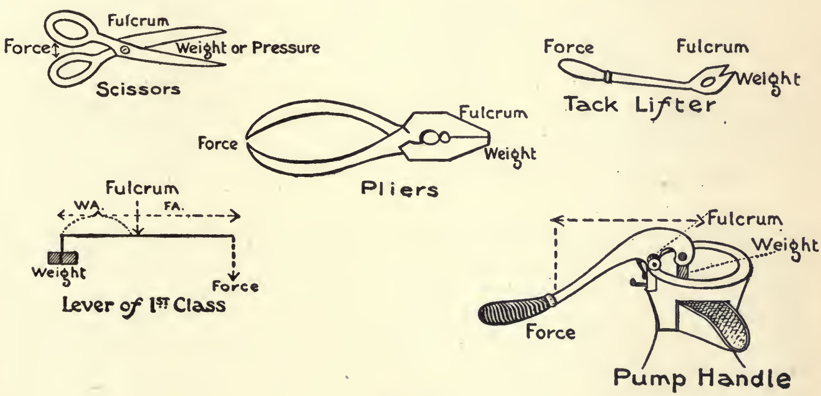

Fig. 370.

products at less expense. Some machines have revolutionized modes of living and methods of doing work.

At one time negroes picked all the seeds from cotton by hand. To-day the seeds are removed by machinery in a fraction of the time required by hand labor in the earlier days. Weaving, sewing, washing, and a great deal of the home work on which people spent many

laborious hours, are done to-day in a much shorter time by machines. Pumps, vacuum cleaners, sewing machines, dynamos, motors, automobiles, mowing machines, harvesters, and hundreds of other labor-saving devices in the home and out of the home make this age an age of machinery.

Simple Machines.—One of the simplest machines may be seen in the crowbar, or scale. Such machines as these are called **levers.** They are divided into three distinct classes—first class, second class and third class.

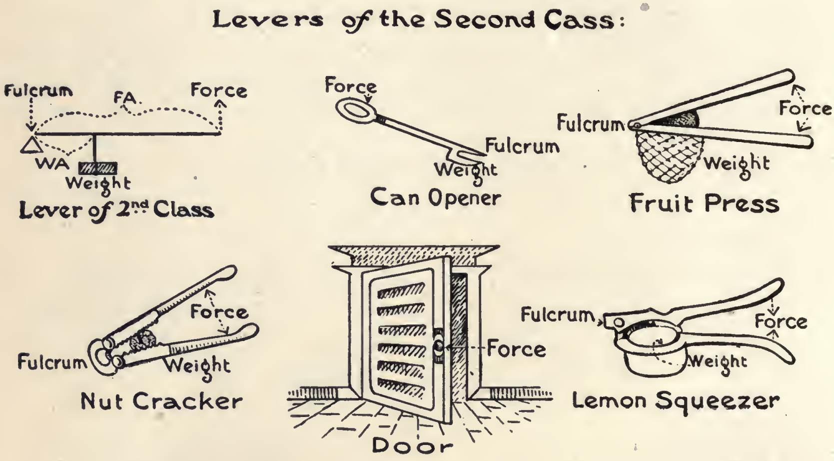

Fig. 371.

First Class Lever.—The first class may be represented by the crowbar, which has been already mentioned. The crowbar is placed over a rock or log, one end under something which we wish to lift, and force is applied in a downward direction at the other end. The rock or log on which the crowbar is resting is called the **fulcrum.** The thing to be lifted is called the **weight**, and the force applied at the other end is called the **power.**

Second Class Lever.—The second class lever may be represented by a nut cracker. Here the power is applied at one end, and the fulcrum is at the other end. The weight (the nut) is between the power and the fulcrum.

Third Class Lever.—The sugar tongs represent an example of the third class lever. The fulcrum is at one end, the lump of sugar (weight) is at the other end, and the force is applied near the center.

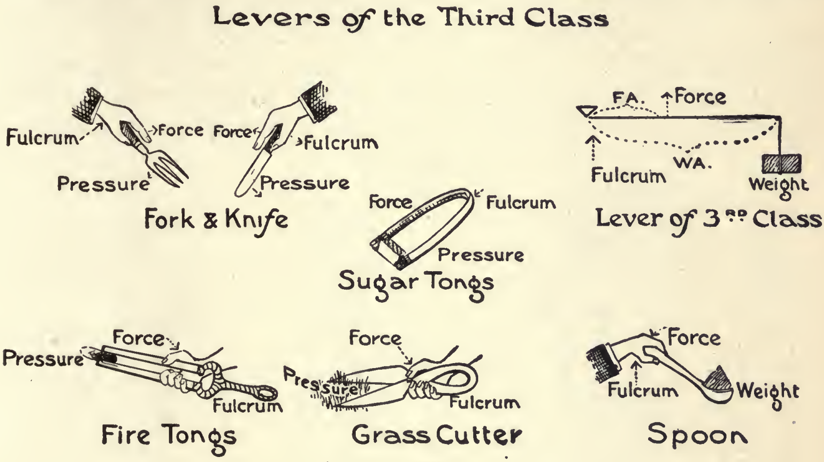

Fig. 372.

Laws of a Lever.—Levers are useful machines since they assist men to accomplish work which otherwise might require a great deal more force expended at one time to accomplish the work to be done.

Fig. 373.

The distance from the fulcrum to the power multiplied by the power is equal to the distance from the fulcrum to the weight multiplied by the weight. In this statement the weight of the lever is neglected, as is usually the case, since it amounts to very little.

Pulleys.—Pulleys are also used as machines for saving power. Barrels, iron bars and other heavy material are often lifted into place by the aid of the pulley.

The illustration will show that if there were no friction, the amount of force needed to lift the weight would be equal to the weight divided by the number of ropes supporting the weight. (Find out by experiment the distance the weight travels as compared with the distance the force travels when pulleys are used.)

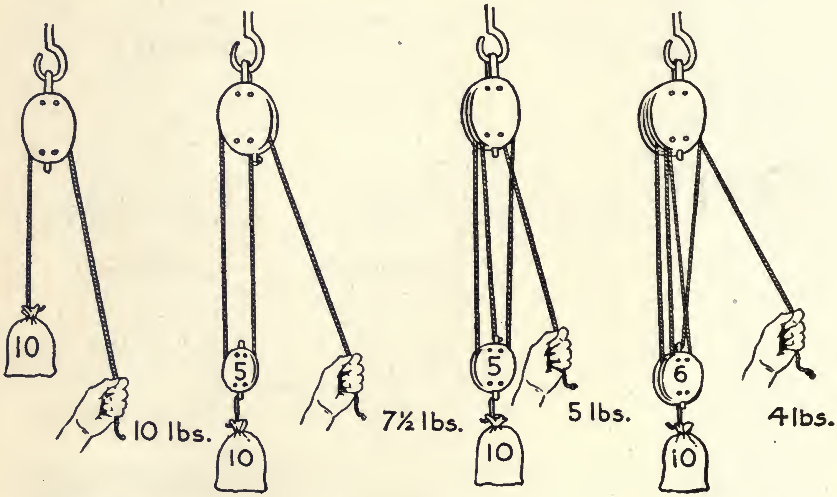

Fig. 374. How many ropes are connected with the pulley pulling the weight in each case? What does the number of ropes divided into the total weight equal in each case?

The Wheel and Axle.—The wheel and axle is, in reality, a lever, the central axle being the fulcrum, the radius of the large wheel the **power arm,** and the radius of the small wheel the **weight arm.** The ice cream freezer, bread mixer, wringer, coffee mill, door knob, etc., are examples of the wheel and axle type of lever.

The Screw.—Another useful appliance is the screw, such as the jack screw, the bolt and nut, the faucet, the meat chopper, the screw, the clamp, the screw on the cover of a preserving can, etc.

With the screw, as with other machines, the distance the weight moves multiplied by the weight is equal to the distance the force moves multiplied by the force. The **pitch** of a screw is the distance a screw will sink into a board or nut, or raise an object on a jack-screw, by turning the screw once around.

The Windlass:

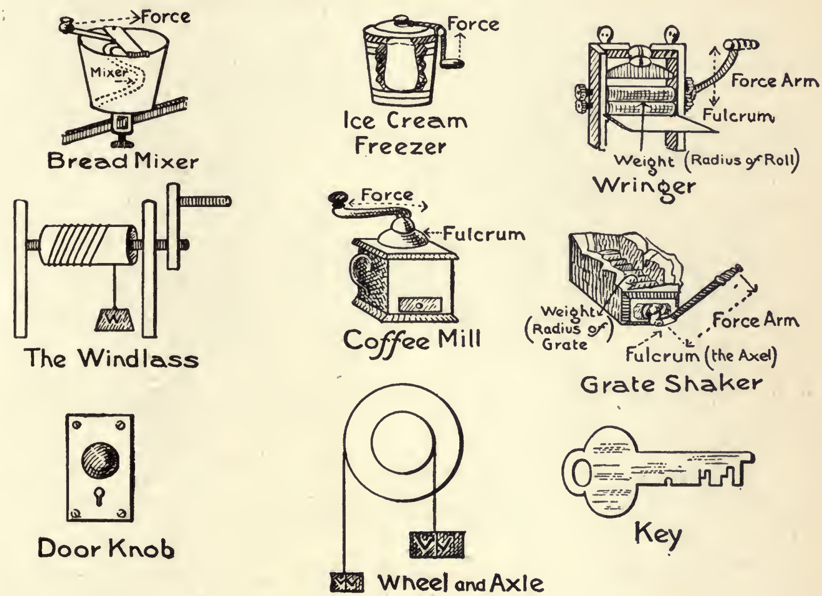

Fig. 375.

In the case of the jackscrew, as shown in the illustration, the distance from the screw to the hand is the radius of a circle. When the screw is turned around once the distance traveled by the power is equal to the circumference of the circle, and the distance traveled by the weight is equal to the pitch of the screw.

What force would be required to raise a thousand-pound weight on a jack screw which has a bar 24 inches long, the pitch of the screw being $\frac{1}{4}$ inch?

Inclined Plane.—It is necessary sometimes to roll heavy barrels into a wagon or truck. A plank is extended from the wagon to the

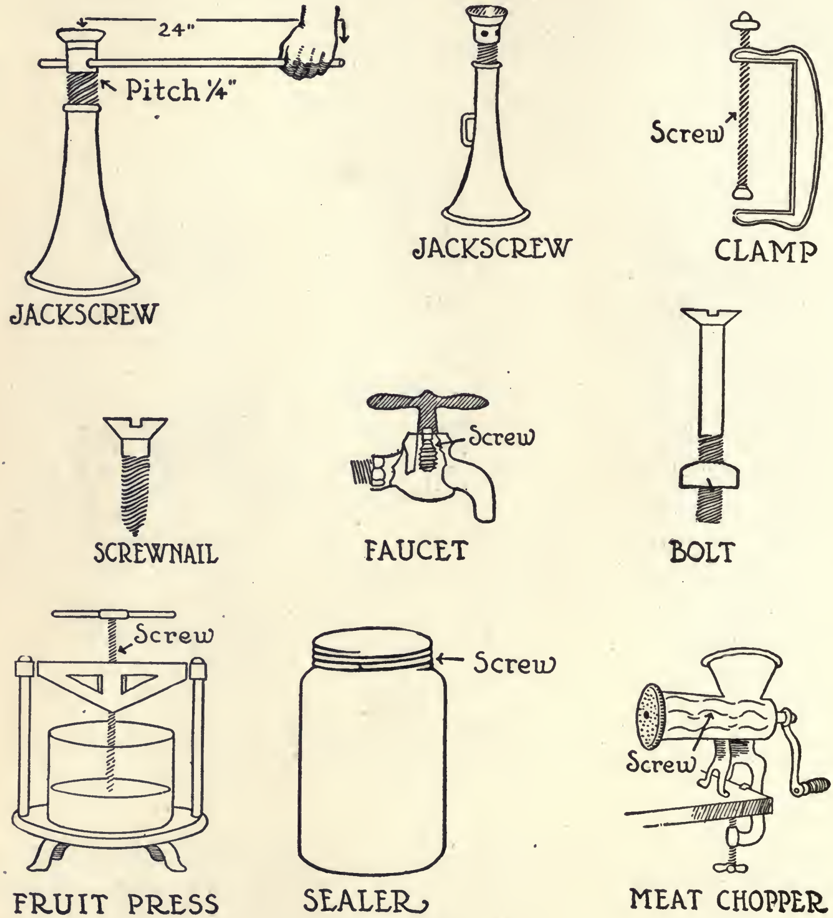

Fig. 376.

ground and the barrel is rolled up the plank. This type of simple machine is called the **inclined plane.** If the barrel is lifted from the ground it would require a great deal of force, but much less

force is used to roll the barrel up the inclined plane. The longer the inclined plane, the less force is needed at one time.

The Wedge.—A wedge is a type of machine which, in reality, is an inclined plane. Such a machine is used for splitting logs, separating objects, etc.

Simple and Compound Machines.—The lever, the wheel and axle, the wedge and the screw are considered simple machines.

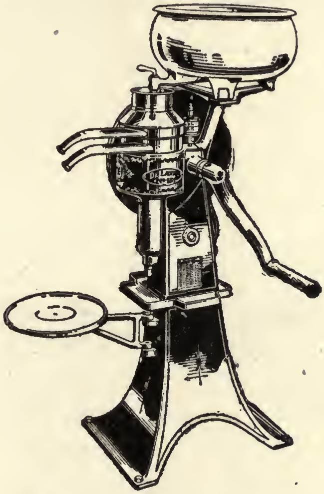

FIG. 377.—The milk separator. A compound machine.

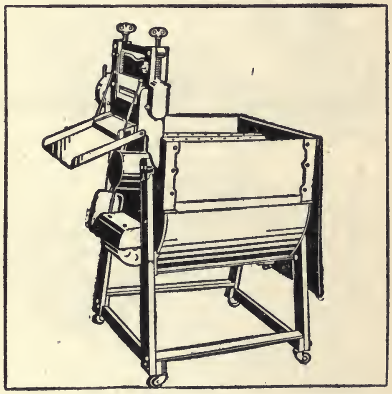

FIG. 378.—How many classes of levers are represented in the washing machine? What other simple machines do you find?

Whenever a machine consists of two or more of these simple machines, it is said to be a compound machine.

QUESTIONS ON DIAGRAMS

1. Where is the fulcrum of a pair of scissors?
2. Where is the force applied?
3. What is the weight?
4. What class of lever is a pair of scissors?
5. What class of lever is a pump? Why?
6. What class of lever is a hammer? Why?
7. What class of lever is a tack puller? Why?

8. What class of lever is a pair of plyers?

9. Tell what class of levers the following are and why:

(1) Can opener.
(2) Nut cracker.
(3) Lemon squeezer.
(4) Potato masher.
(5) Door.
(6) An oar when one is rowing a boat.

Fig. 379.—What class of lever is the paddle of a canoe? What class of levers are the fingers on the strings of the banjo?

Fig. 380.

(7) An oar after being pulled out of the water and lifted up preparatory to taking another stroke.
(8) A knife.
(9) A fork.
(10) Fire tongs.
(11) Spoon.
(12) Sheepshears.
(13) Typewriter key.
(14) Piano key.
(16) Arm.
(17) Jaws.

380a

10. Why is a finger more likely to be crushed if caught in the door near the hinge than near the latch?

Work.—Whenever a person exerts force through any distance, such as shoveling coal, lifting a stove cover, raising a window, walking upstairs, etc., work is accomplished. Work is measured in **foot pounds.** A foot pound of work is accomplished when a pound is raised a distance of one foot. A **horse power** is equal to 550 foot pounds in one second.

Friction and Mechanical Advantage.—A great deal of work is done to overcome friction. For that reason perpetual motion

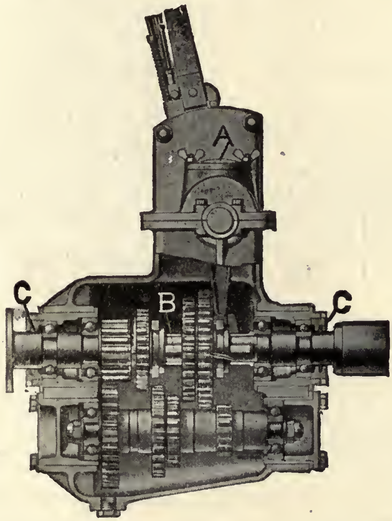

FIG. 381.—Automobile transmission. Find as many mechanical advantages as possible. Tell why they are mechanical advantages.

FIG. 382.— Dish-washing machine.

machines can not exist, for more work always has to be put into a machine than is actually obtained from the machine. Machines do not save work, but permit a smaller **force** to be applied for a longer time.

Machines are used by men to gain some advantage, and this advantage is called the **mechanical advantage** of the machine. Many things may be moved with a crowbar which could not otherwise be moved. A hammer will draw a nail which could not be drawn

by a man without the aid of a hammer. Machines which save force are said to have a mechanical advantage of force.

Some machines have a mechanical advantage of **speed.** Many of the common machines around our homes, such as the mowing machine, the egg beater, the sewing machine, etc., have a mechanical advantage of speed.

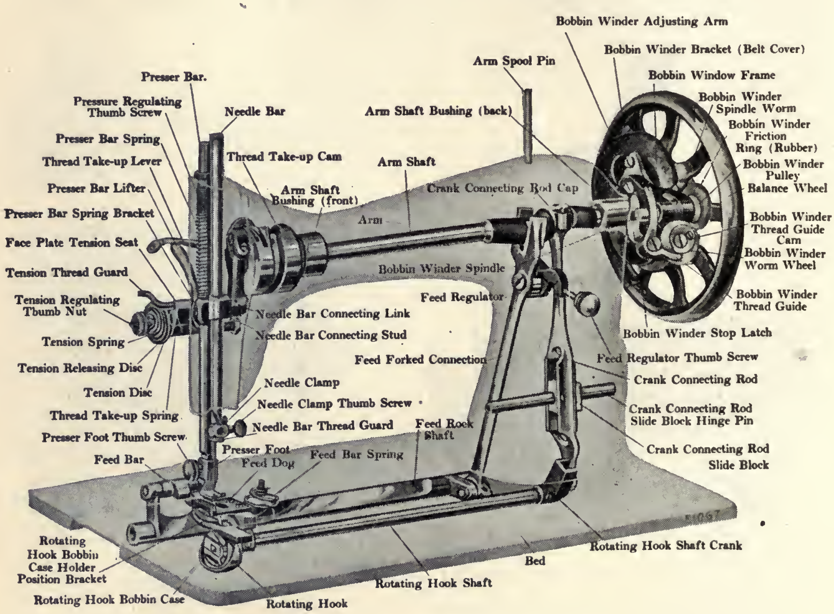

FIG. 383.—The Sewing Machine.

Still other machines, such as the typewriter, the handle of a pump, a pulley, have a mechanical advantage of **position** or **direction.** Machines may have several mechanical advantages, but it is impossible for machines to have a mechanical advantage of speed and mechanical advantage of force at the same time.

The Amount of Work a Horse Does.—A horse walking at a rate of $2\frac{1}{2}$ miles per hour should not exert a force of more than $\frac{1}{10}$ to $\frac{1}{8}$ of its own weight, if the horse is doing continuous work all day.

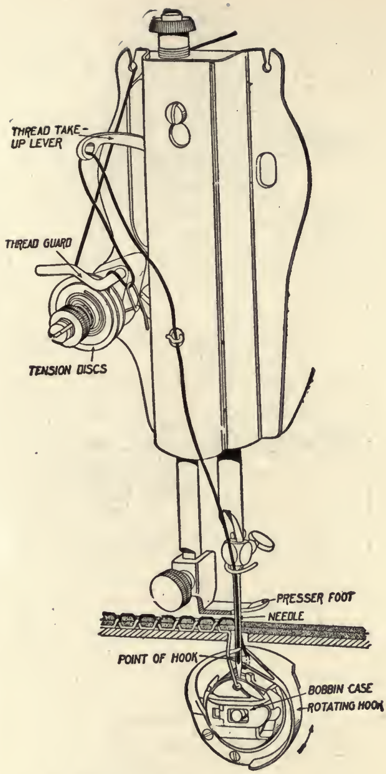

FIG. 384a.—Rotary Hook, First Stage in Stitching.

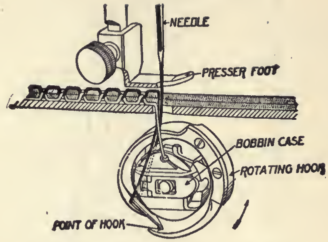

FIG. 384b.—Second Stage.

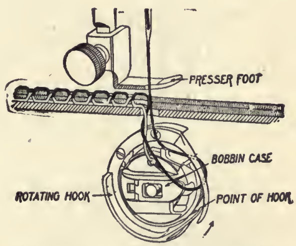

FIG. 384c.—Third Stage.

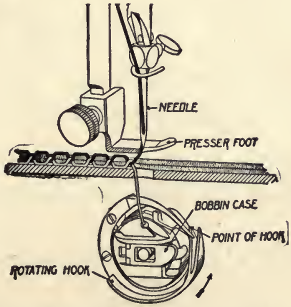

FIG. 384d.—Stitch completed.

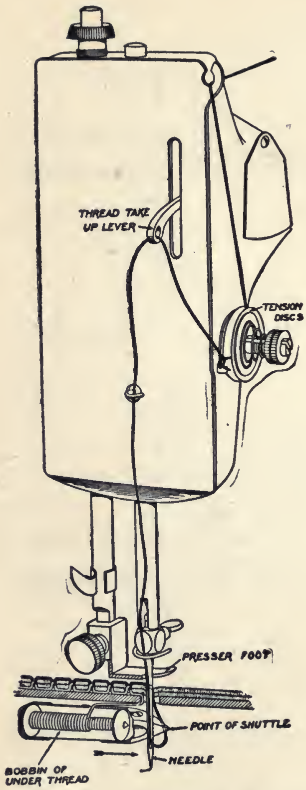

FIG. 385*a*.—Vibrating Shuttle Sewing Machine. First stage in stitching.

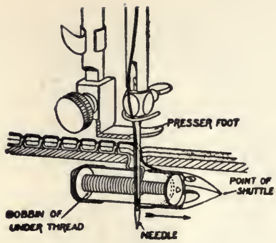

FIG. 385*b*.—Second Stage.

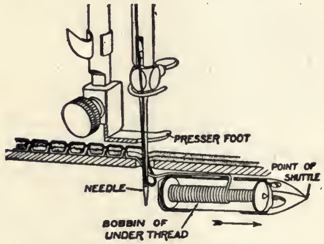

FIG. 385*c*.—Third stage.

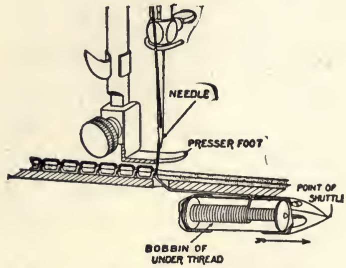

FIG. 385*d*.—Completed stitch.

Questions

1. Find some examples in your home of the wheel and axle.

2. Why is the wheel and axle principle used in the particular things mentioned?

3. Find an example where pulleys are used, and tell why they are used?

4. Why is it easier to draw a heavy boat ashore with pulleys?

5. If you were pulling 50 pounds on the end of a rope with 4 pulleys, about how heavy a boat could you pull ashore?

6. The circumference of a wheel on a letter press is 30 inches, the pitch of the screw is $\frac{1}{2}$ inch; if the force is exerted on the wheel, with what pressure would letters be pressed together in the letter press?

7. A person weighing 150 pounds walks upstairs to a height of 15 feet. How much work did the person do?

8. How much work would be required for you to walk upstairs in your home?

9. What horse power of work would be accomplished if it took you 5 seconds to go upstairs?

10. How much work would a horse do if he pulls on a load with a force of 100 pounds and travels 5 miles?

11. A man is shoveling coal into a furnace. Each time he lifts a shovelful of coal, he carries 10 pounds of coal from the floor to the furnace door, a distance of 2 feet. How much work does he do to accomplish this, if he puts 5 shovelfuls of coal in the furnace?

12. Why is it easier to push a barrel of molasses up an inclined plane (plank) into a truck than to lift it directly up?

13. Why are machines oiled?

14. Why do some machines have ball bearings?

15. Name some machines which use ball bearings.

16. Why does a clock need oiling?

17. Why does it not keep good time if it has not been oiled for some time?

18. What is a " hot box "?

19. What is the result of friction?

20. What mechanical advantage has a sewing machine, a bread mixer, a meat grinder, fire tongs, vacuum sweeper, door knob, oars in a rowboat?

21. Name some machines you have at home and tell their mechanical advantage.

22. How much should a horse pull if he weighs 1000 pounds, 1600 pounds, 2000 pounds?

23. What horse power would these horses exert doing work at the rate of $2\frac{1}{2}$ miles per hour?

CHAPTER XV

"SAFETY FIRST"

CAUSE AND PREVENTION OF ACCIDENTS

Thinking.—Thinking always of "Safety First" is first aid to the uninjured, and renders first aid to the injured unnecessary.

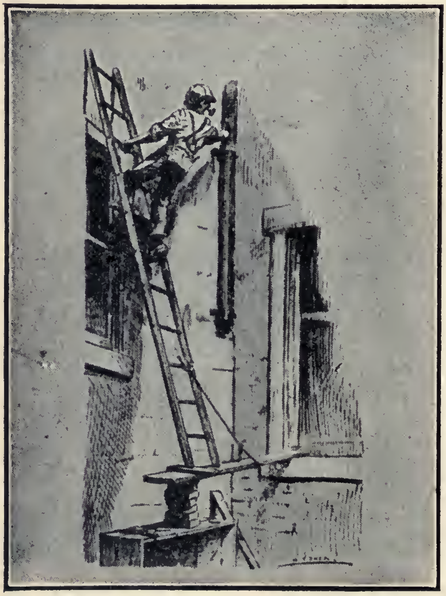

FIG. 386.—When he gets back from the hospital, he will tell about his "accident," and talk about his bad luck.

Many of the lives lost and many of the cripples in our country could have been saved, if people had stopped to think. "If I had only stopped to think," is a phrase often used by people who have been injured or have been the cause of some accident.

The Thoughtless Man.—In most cases the man who is always having "Hard Luck" and getting hurt is the man who is thoughtless about his safety. Such a man may climb a ladder which has not been firmly placed on the ground. He takes a chance, gets hurt, and people say he is always getting injured. "He has such hard luck."

Chance Taking.—"A chance taker is an accident maker." Whenever we hear of people taking chances, and especially unneces-

sary chances, we must necessarily class them as criminals of a certain type, since they not only endanger their own lives but often the lives of many innocent persons.

People will cross the street in the middle of a block, or they will take a chance on escaping injury by crossing a street against traffic and against the policeman's signal for closed traffic. An automobile driver may try to get ahead of a train at a crossing when the time saved would probably amount to only a fraction of a minute. He may not succeed and terrible consequences follow.

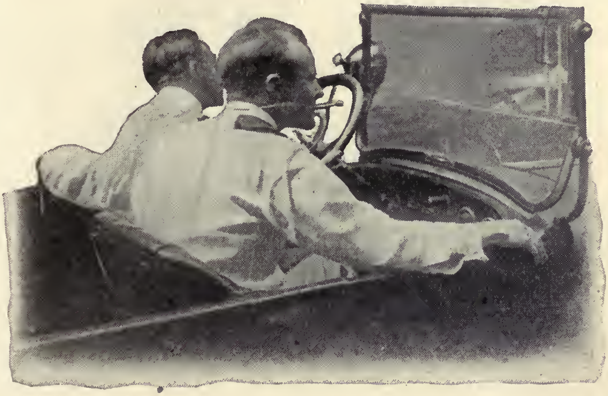

FIG. 387.—The man who tells the driver to "Let her go," is bidding for a place in a long black procession. This man is a menace to the community, for he cares nothing for others' safety.

Caution should not be confounded with fear, and the exercise of caution, the habit of consideration of "Safety First," need in no manner interfere with work or recreation. There is no rational thing which we desire to do that cannot be done in a manner consistent with the thought of "Safety First."

Hurry.—One must not think that speed means hurry. The former is necessary and desirable, but the latter is unnecessary, undesirable, and unworthy of a person who organizes his activities so as to obtain the greatest efficiency in the quickest time possible.

Hurried minds and bodies are not at their best. Nothing done hurriedly is ever done as well as it could have been done. There is

little excuse for saying, "I was in such a hurry." Such a phrase often tells us that people are not doing things thoughtfully, conscientiously, earnestly, and in a well-systematized way. To hurry means to waste energy, physical and mental. This characteristic hurry is responsible for most of our accidents. Thought is the cornerstone of conservation and efficiency. Use thought. Eliminate hurry, worry, carelessness and injury.

FIG. 388.—"Oh! Look, look, quick!" What do you think might happen to a driver who is in the habit of looking in directions other than the direction in which the automobile is traveling? What should he do before he follows the direction of the other fellow's finger? The fellow who sits beside the driver is careless, thoughtless and indifferent to his welfare as well as that of other people. Thousands of terrible accidents are caused every year through this kind of carelessness.

Do things well.

Accidents do Not Happen; They are Caused.—What we are in the habit of calling "accidents" can not occur except through lack of thought; the child intent on its play, the adult intent on other matters, is the victim of an "accident." People who give no thought to the danger permit the child to play with a bonfire or matches; permit the child to make the highway a playground, notwithstanding the fact that there are vacant lots, yards, and, in many municipalities, regularly maintained children's playgrounds. The automobile operator, the horse driver, the motorman and the

locomotive engineer are too often blamed for injuries sustained by children when the blame properly rests upon the parent, guardian, teacher or passerby who failed to point out the dangers. It is possible, by setting a good example, and by repeated words of caution, to succeed in training others to think " Safety First," and to realize that the chances taken because of lack of thought, even though they may not result in personal injury or death, are out of all proportion to the pleasure gained or the time saved.

Questions

1. Why should ladders be provided with spikes and be firmly placed on the ground?
2. Why is it better in climbing a ladder to keep the hands on the sides of the ladder rather than on the rungs?
3. Name some common ways of taking chances.
4. What is meant by caution?
5. Name some accidents, and show how they did not *happen*, but were *caused* by thoughtlessness.
6. Why should the driver of an automobile be careful to have two lights on the front of his car.
7. Why are strong headlights on an automobile dangerous?
8. Why should an automobilist who is driving with strong lights, slow down and dim the lights when passing another, especially in the country?
9. Why should one always look for himself at a railroad crossing, rather than depend upon bells or the watchman?
10. Why should you never put your trust in fire-proof buildings?

DANGERS IN AND ABOUT THE HOME

Accidents about the Home.—The appalling number of accidents happening in and about the homes of America demonstrates the necessity of considering " Safety First " there as well. Standing on the arm of a chair or an old, dilapidated step-ladder to reach the pictures or curtains; neglecting to repair partly broken stair steps; forgetting to light the dark passageway to the cellar; failing to pick up and put aside box lids and other boards which hold pro-

truding nails; failing to repair guards or keep closed the doors over cellar entrances—all of these often result in serious accidents. Leaving garden or house tools lying on the floor or ground is a small thing, but it shows a lack of careful thought, and very frequently results in serious injury in and about the home.

Matches and Fire.—Matches should be kept in a metallic box, out of reach of small children. Matches which can be lighted only by striking them on the box are far safer and no more expensive than ordinary matches. Children should never be left alone where they can possibly play with a fire in a fireplace, stove, or elsewhere.

The bonfire burning in a gutter or a vacant lot surrounded by laughing children may be the prelude to much terrible suffering for one of the children. Such a thing is indicative of carelessness and lack of thought on the part of the parent, guardian, big brother or sister; and it is evidence of neglect of duty by the passerby or the police. To report to the authorities that children are playing with fire is to show yourself a true citizen, interested in the safety of the community as well as the safety of the children.

1. Always study to prevent fires in the house or place of business.

2. Always give attention to fire prevention; an ounce of prevention is worth a pound of cure.

3. Always remember that to have fire prevention in your home is better than to mourn over the remains of your beloved ones, or to have the sympathy of your neighbors over your loss.

4. Always remember that a house of merriment is better than a house of mourning.

5. Always be prepared to put fires out before they become dangerous.

6. Always be prepared in case of fire to save every person in your building; plan before the fire occurs.

7. Always know where the nearest fire alarm box is situated, and keep the call number of your fire department in plain sight near the telephone.

8. Always call the Fire Department as soon as the fire is discovered.

9. Always see that fire drills are held at least once a week in every school or factory.

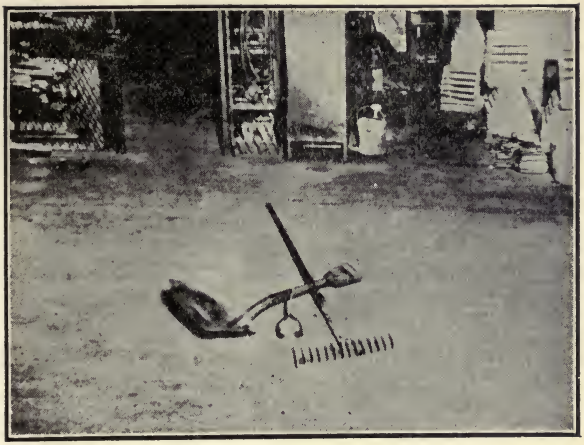

FIG. 389.—Don't leave them so: put them away: broken bones and lockjaw have resulted from this.

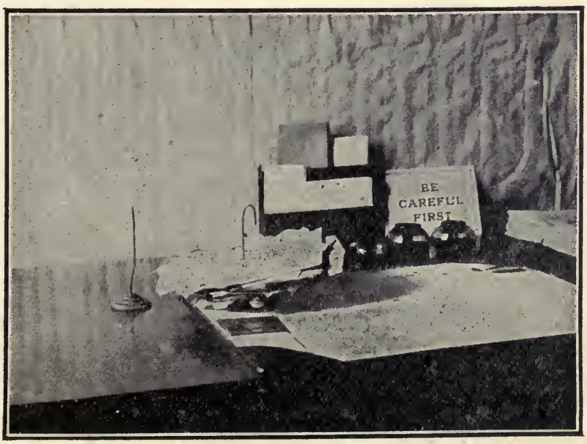

FIG. 390.—Turn down all dangerous points. A slight scratch may result in blood poisoning.

10. Always keep your supply of matches in metal boxes throughout the house.

11. Always remember that the flames of the match, improperly, carelessly, thoughtlessly, or wantonly applied, result in the destruction of property, and in death.

12. Always extinguish a lighted match before you throw it away.

13. Always insist on having an outside shut-off attached to your gas supply pipe so that gas may be turned off from the street.

14. Always avoid rubber hose connections for your gas stoves.

15. Always see that all kerosene oil is kept in a closed metal can in a safe place.

16. Always see that all lamps are filled by daylight, burners kept clean and wicks changed often.

17. Always have your chimneys, stovepipe and stoves examined and cleaned once a year to avoid any danger of fire.

18. Always see that your stove or range is in good condition, and that no spark or live coal can fall on the floor.

19. Always see that all ashes are placed in a metal, tightly-closed receptacle.

20. Always keep your buildings clean and free from rubbish, etc.

21. Always have a full pail of water on each floor in the house to put out a starting fire.

22. Always insist on fire-resisting material to cover the roofs of your buildings. A shingle roof is the best kind of a fire catcher.

23. Always keep fire escapes in good condition, well painted and clear of all obstructions.

24. Always have your steam boilers examined twice a year.

25. Always have a stationary iron ladder leading to the roof of your building, instead of a movable wooden ladder.

Gas in the Home.—When the odor of gas is detected about the home, the gas must be escaping because a fixture is loose or defective; because some one has only partly turned off the gas; or because the pilot-light for the matchless gas range, or some large gas light has gone out.

Illuminating gas is inflammable and explosive when mixed with the proper amount of air. A leak should never be hunted for with

a lighted match or candle. Such carelessness has brought about terrible explosions which have resulted in many fires, deaths and much destruction of valuable property. Illuminating gas, as we have already learned in Chapter VI, may cause *asphyxiation.* Gas fixtures should be carefully looked after to see that the stop-cocks turn with some difficulty. Coal stoves generate a very dangerous gas similar to illuminating gas. Dampers must be carefully adjusted to allow this gas to escape up the chimney.

Sewer gas may cause sickness and headaches. Tests should be made for leaks in sewer pipes, as described on page 285.

The Use of Gasoline and Benzine.—Gasoline and benzine are often used for cleaning purposes. We have already learned that the vapor spreads very rapidly when either liquid is exposed to the air. This vapor is very inflammable, and many people have lost their lives by the use of gasoline or benzine without taking proper precautions.

Poisons. Too many people are careless regarding the labeling and storing of medicines. We often read of deaths caused by some deadly poison taken by mistake because it was in the medicine closet. This shows that every one should have a special place for poisons used to kill flies and mice, or for other purposes. All bottles should be conspicuously labeled, and kept where children cannot get them, and where adults will not take them by mistake. Medicines which are to be taken internally should never be kept in the same closet with any poisons.

Decomposing Matter.—Whenever matter decays it generates gases that are in most cases dangerous. Food materials easily absorb these gases and thus become unfit for food and often poisonous for babies and young children. Flies and vermin which carry disease germs to food breed in matter which is decomposing. We should be very careful never to leave about the house, yard, alley, or streets any material which will decay, because it may be the means of causing sickness or even death.

Broken Glass or Rusty Nails.—The germs of blood poisoning or lockjaw are introduced into the system through cuts and bruises. Broken glass or rusty nails may be the cause of much suffering. Whenever we see these things lying around, let us make it a point

to pick them up and dispose of them in a safe place, to insure the safety of the community.

Electric Wires.—Electric wires which are not well insulated cause many fires. We should be sure that all wires which lead to lamps, vacuum cleaners, etc., are well insulated, and are not left near material which would take fire if a short circuit occurred in the wire. When leaving the home for a period of weeks or months, the electricity should be turned off from the house, since the wires might cause fire during this time.

Open Holes, Pits, Cellarways, etc.—Many accidents have been caused by leaving manholes open, around which no iron railing has been placed. Cellarways with entrances to the sidewalk should be carefully guarded when open. Only those who are working about manholes and open places in the street should be allowed to stand near them, for frequently plumbers will be found there using their small gasoline furnaces. Children have been hurt or seriously injured by the explosion of one of these furnaces, or have accidentally overturned the furnace and been terribly burned in the eyes and elsewhere by the molten metal.

Obstacles in the Path.—All boxes, sticks, boards, pipes, wire and other obstacles in the path where people walk should be picked up. Such things may cause very serious injury. Broken knee-caps, ruptured blood vessels in the leg, concussion of the brain, and bad cuts on the face and scalp have been suffered by people who tripped over such material.

Flying Objects.—Care should be taken to see that all tools used have the handles securely fastened on. A hammer head flying from the handle may cause a terrible injury. A loose axe-handle may mean the loss of someone's life. A little attention to these things which are used every day will prevent a great deal of pain and suffering.

Questions

1. What should be done if the stopcock on the gas fixture turns too easily? Why?

2. Why should the gas always be turned out beyond the rubber or silk hose?

3. If an extension cord is used to light a lamp, where should the current be turned off when the lamp is not in use? Why?

4. Why should one never hang clothes on the gas fixtures?

5. Why should the windows of the sleeping room always be kept open during the night?

6. Why is it bad to have swinging lamps or gas brackets near a window?

7. Why should a stove have a metal protection on the floor under it?

8. Why is it bad to have a stove pipe in contact with a partition?

9. Why is it a bad practice to put kindling wood in the oven?

10. Why should gasoline, benzine or naphtha never be thrown down a sink, cesspool or sewer?

11. Why should one never leave a lamp burning or a gas light turned down low when no one is in the house?

12. Why should one avoid cleaning clothes with gasoline in a room?

13. What kind of matches is best to use around the home? Why?

14. Why should one never pull a chair from under a person who is just about to sit down?

15. What should be done with all poisons which you may have in the house?

16. Why is decaying matter a source of many diseases?

17. Why are red lights necessary where work is being done on the road?

18. Why should a clothes-line be placed higher than a person's head, especially on a lawn where people are apt to walk after dark?

19. What injuries may be caused by obstacles such as boards, sticks, and wire lying about the home?

DANGERS OUTSIDE THE HOME

Railroads.—The greatest danger outside the home is the railroad crossing. If we are riding in an automobile and there are no gates for protection at a railroad crossing we are criminally negligent if we do not stop or slow down to be sure that there are no trains approaching. We should never try to cross a track when the gates

are closed or when the watchman has signaled for us to stop. Walking on the railroad tracks also may cause loss of life or result in a terrible accident which will injure or maim for life.

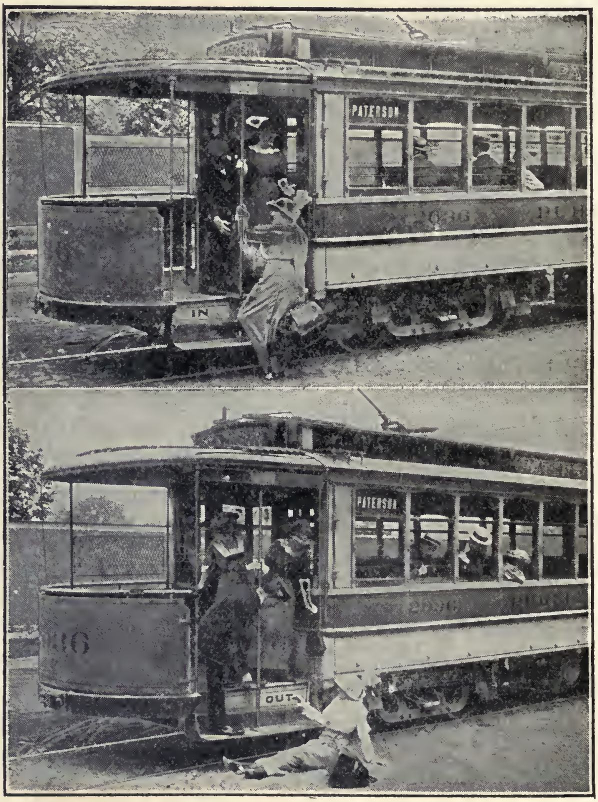

FIG. 391.—When alighting from a car face the direction in which the car is traveling. The top picture shows a young lady getting off a car in the wrong way. The result is shown in the bottom picture. The car started before she had both feet on the ground.

Boarding and Alighting from Trains.—One should never attempt to alight before the train has come to a full stop. The practice of attempting to overtake a train as it leaves the station and of jump-

ing aboard after the train has started is responsible for many injuries, and always involves great danger.

Street Cars.—In most cases people enter and leave on the right-hand side of street cars. For this reason, the left hand must be used upon entering or leaving a street car. By using the left hand in alighting from a car, a passenger is always facing the direction in which the street car is moving. A good rule to remember is "The right hand is the right hand for packages and books." Sometimes people enter by the rear of the car, and alight from the front. Here

FIG. 392.—He paid with his life for a short ride. It was not worth it.

is a great element of danger, for the person who does not alight properly leaves a car so that his back is toward the direction in which the car is traveling.

If any part of a passenger's clothing catches on the steps and the car starts before it is disengaged, he may be thrown backward, with the possibility of having an arm or leg injured by the wheels. In the case of such accident he will have a greater opportunity to save himself if he is facing the direction in which the car is moving.

Stealing Rides.—A great number of children are killed each year by wagons and cars because of the "stolen ride." A boy

riding behind a cart or truck may drop into the street only to be run over by a car or another truck which is following. He may dodge out from behind the car on which he has stolen a ride only to be struck by an automobile. Some part of the truck may give

FIG. 393.—Did this ride pay? Who is to blame?

way, or the tail board may break loose from its fastening and let two or three boys drop on the pavement with the great probability of their being injured.

It is our duty, when we see boys stealing rides on trucks and cars, to inform the drivers in order to protect the lives of the boys.

Thoughtful boys do not place themselves in such dangerous positions, for they not only endanger their own lives but they risk placing the blame for their possible injury or death upon an innocent driver.

Elevators.—Many accidents occur from carelessness around elevators.

The following accidents are good examples of thoughtlessness and carelessness.

1. Boy was standing at elevator shaft, second floor. As automatic doors were raised, boy looked over door to first floor. Head caught between door and platform of car, severing head.

2. The man forced open the doors opening into the elevator shaft and evidently looked down the shaft. The descending elevator caught his head, and the operator found the body lying on the floor with the head wedged between wall of shaft and floor of car.

3. The deceased was holding on to elevator with both hands (under floor of car). The elevator was ascending from first floor, in charge of other persons. The boy lost his hold and fell to basement in elevator pit.

Fig. 394.—Call the boy down: Any wire may be "a live wire." Make it your business to prevent a funeral.

And so on through the list. In many instances, in fact in almost every one, the men or boys are themselves to blame. Accident 3 especially shows the desire to be "smart." This boy was seventeen years old and, as far as can be learned, wanted to do the "original" thing.

Avoid leaning against the elevator door.

Do not attempt to open the elevator door to enter or leave. The operator should attend to this.

Shafts, Bolts, Pulleys and Gears.—Some of the accidents causing injury from shafts, pulleys and gears teach a valuable lesson.

Here are a few accidents which were due entirely to thoughtlessness.

1. Internal injuries and broken legs. Caught on a piece of smooth shafting that runs about 2 feet above platform.

2. Back broken. Boy climbing up to revolving shaft, in turning to go back to his work, slipped and was caught by shaft.

3. It is not known whether he was about to step over line shaft or to repair a belt, when he was caught on revolving line shaft. His body struck a pier, and he was dead when first discovered.

4. It is assumed girl was looking for bad shell in back of machine, when, on raising her head, it struck the driving shaft of machine, causing the scalp to be torn completely from her head.

5. One other which fortunately did not prove fatal. She was in the act of combing her hair at the back of the roving frame, supposedly bending over and combing her hair downward, and her hair became caught around the lower back shaft of the frame. This same accident occurred to two different girls just about a year apart. The true solution of it is that both girls, in their rush to get out early, stole the company's time for a hasty toilet rather than go to the dressing-rooms after dismissal.

6. An accident that almost proved fatal occurred to a lad of seventeen, no one being able to give a reason for his being where he was. As nearly as can be determined, the boy was trying some experiment with a piece of rope attached to an iron bar. The rope wound around the shaft (which was some 8 or 9 feet above the floor) caused the iron to whirl around and strike him on the head, fracturing the skull. In this instance the shaft appeared so inaccessible as not to need covering, yet the boy managed to get injured by it.

Firearms.—Firearms of all sorts are dangerous. They are made to kill. Children should not be allowed by older people to handle them.

Never point a gun or pistol at any one. It is nearly always the gun or pistol that was thought to be unloaded that does the killing.

When several men are out hunting, if they separate, they should have an understanding where each is to go, so that they may not shoot each other.

Be careful about shooting a long-range rifle. The balls from some rifles, when held at a proper angle, carry for several miles.

Boating.—Many lives are lost annually on the water. Both swimming and boating have peculiar dangers of which those who indulge in them should be aware.

A boat is no place to *play* in. Never rock the boat. Never try to exchange seats in deep water. Never stand up when the boat is away from the shore. Do not lean over the side of the boat.

Conclusion.—Conservation is the trend of the times, the order of the day. The most worth while thing is the conservation of health and human life. It is the duty, and should be the pleasure, of all people to aid in this conservation by precept and example, in the home, in the place of business, and on the street. A few words of caution may help the unthinking person to observe "safety first" principles. In *thinking* "safety first" we need not miss any pleasure or leave duty undone; we simply perform our acts without hurry and in the safest possible manner.

The results of the policy "safety first" will be that the boy may grow up to enjoy his manhood and the girl her womanhood; parents will not lose their children in their youth, or be deprived of their companionship and support in old age; adults will not be killed in their prime of life, and cripples will no longer be the by-products of civilization.

S Steam and street cars.
A Automobiles.
F Fire.
E Electricity.
T Teams and Think.
Y You! the person who must think of "safety first."
"Don't take a chance."
"The right hand is the right hand for bundles."
"Start early. Don't hurry."
"Wait until the car stops."
"Fire is a good servant but a terrible master."

"The 'unloaded' gun frequently kills."

"Trolley and railroad tracks are the giants' sidewalks. You have your own."

"A wire is a dangerous thing; let it alone."

"Gas brackets are not clothes hooks."

"Wait for the fire to kindle, or rebuild it. Don't hurry it with oil."

"Stolen rides often cost too much."

"Play in safe places only."

"Let cars, automobiles, motorcycles, and wagons go past first."

"Work, play, travel; but always think

"SAFETY FIRST."

Fig. 395.—Mutilated; inefficient. The best safety device is a careful man.

Questions

1. Why is roller skating dangerous in a street on which there is considerable traffic?

2. Why is it best never to climb poles on which there are wires for the transmission of electric currents?

3. If standing in a wagon or car why should one be careful to hold on to some part of the vehicle when it is about to start?

4. Name some of the dangers and accidents which may occur from riding on the backs of wagons, automobiles and cars.

5. Hold books or bundles in the hand in which they should be held while alighting from a car.

6. Why should passengers in cars which show the sign, "Do not lean against the door" obey instructions?

7. Why should one never put his head or arms out of the window of a moving car?

8. Why should the companion of an automobile driver never call his attention suddenly to anything so out of his line of vision that his head is turned away from the road?

9. Carbon monoxide is one of the gases from the exhaust of an automobile. Why should one always open the door of a garage before starting the engine?

EMERGENCY TREATMENT *

Emergency Outfit.—

One 4-ounce bottle of "Synol soap" or soft soap liniment.
One 4-ounce bottle saturated solution boric acid.
One 1-ounce bottle flexible collodion.
One 1-ounce bottle 1–1000 solution adrenalin chlorid.
One 2-ounce bottle aromatic spirits of ammonia.
One pair scissors.
Four 1-ounce packages Red Cross absorbent cotton.
Four 1-yard packages sterile Red Cross gauze.
Six 2-inch gauze bandages.
Six 3-inch muslin bandages.
One roll 2-inch adhesive plaster.
One paper medium safety pins.
One hand brush.

Note.—Plaster, collodion, and similar substances seal the wounds on which they are used so that if any pus germs have been introduced they are in the most favorable condition for doing harm. The use of plaster (except court plaster, to cover a trivial scrape not involving the entire thickness of the skin) must be absolutely condemned, for not only does plaster seal the wound, but it is also very likely not to be surgically clean. Collodion is not surgically dirty, like plaster, and as the ether which it contains has some antiseptic properties,

* From State Monograph of New Jersey, The Teaching of Hygiene and Safety.

it is not really as dangerous as plaster. But it also may seal up germs under it. A good rule to adopt is to use it only on slight, cleanly-cut wounds made by sharp instruments, and to have it removed by a surgeon if inflammation sets in.

Slight Cuts (Skin Wound with Slight Bleeding). Such cuts should be thoroughiy cleaned with *soap* and *hot water*, and the bleeding stopped by steady pressure with a little cotton which may be wet with adrenalin solution. This preparation is of value only in slight superficial bleeding and is useless in severe hemorrhage. If the part cut was not very dirty at the time of injury, and the cut was made by a clean instrument or substance, a little cotton may now be applied and saturated with collodion, which dries and hardens into a protective covering. This may be hastened by blowing on it. The collodion should not be applied until the bleeding has stopped and the edges of the wound are dry. It should never be used where there is danger of infection from dirt that may have entered the wound. In the case of scalp wounds the hair should be clipped for half an inch or more around the edges to give opportunity for cleaning and treatment.

Iodine will kill all germs. Peroxide of hydrogen should not be used if the wound is to be covered.

Moderate Cut (Deep, or with Free Bleeding).—Cuts of a more serious grade than the above should have the bleeding stopped by pressure with a small piece of gauze or cotton which may if possible be wet with water as hot as can be borne. If this is not available, ice or snow may be used, but pressure must be the main reliance. The skin of the part and the edges of the wound should be thoroughly washed—scrubbed if possible—with *hot* water and soap, and then a piece of cotton wet with the boric acid solution applied and retained by a tight bandage, making sufficient pressure to stop the bleeding. The same treatment should be used for a slight cut made with an unclean instrument. In either case, the wound should be seen by a physician as soon as possible.

Severe Cut.—A cut involving a large artery is recognized by the jet of blood with immediate profuse hemorrhage. In such a case *firm pre sure* by the *finger at once* at the point of injury is called for to stop the bleeding, as otherwise the loss of blood may be so severe as to cause collapse, or even death, while other measures are being

prepared, even in a minute. The finger thus employed must not be removed till the supply to the artery involved is controlled by the application of a muslin bandage around the arm or leg between the body and the wound, and twisted tight with a stick. After the bleeding is stopped, the wound may be washed clean as before, dressed with cotton held in place by a bandage, and the patient referred at once to a physician, who should have been sent or as soon as the injury occurred.

Nosebleed.—Pack the bleeding nostril with a long twisted piece of cotton soaked in an adrenalin solution and thick enough to fill the nostril. Keep the patient quiet. Any nosebleed not controlled in this way in a few minutes should be referred to a doctor.

Bruises.—To prevent " black eye " or other discoloration in case of bruises, apply a cloth wrung from cold water. The cloth should be continuously applied and *kept cold.*

Burns.—Put the burned hand or finger in cool water to soothe the smarting. Apply a little common baking soda and afterward vaseline, fresh lard or cream.

Particle of Dust, Cinder, etc., in Eye.—When a " foreign body " flies into the eye, the resulting sensation of pain causes an instinctive squeezing of the lids together, and often a tendency to rub the eye. If the particle is small and not sharp, pain may be slight or absent, and the only sensation may be irritation and watering coming on later. If the eye be kept closed and quiet, often the tears will suffice to wash out the offending particle. Never wink or rub the eye as this may cause scratching and injury to the delicate surface of the eyeball. If the speck is not washed out in this way, separate the lids with the fingers, and search closely, under a bright light, first the inner surface of the lids, then the whites and finally the cornea, or clear part of the eye, for any speck on them. Very minute particles often cause severe discomfort. The inner surface of the upper lid may be readily exposed to view by pulling it downward by the lashes and then turning up over the point of a pencil. When found, the speck may be removed by wiping with the corner of a handkerchief, or a little cotton wrapped on the end of a match or toothpick. If this does not suffice, no further effort should be made to remove it, but the person should be referred to a physician;

many eyes are seriously injured and some lost as the result of injury in the attempted removal of such particles by unskilled hands.

Stings.—Remove the sting first either by squeezing or with a knife. Apply wet mud to prevent swelling.

Poison Ivy.—The ivy which is poisonous is that which has three leaves; not the five-leaved. This is found clinging to fences and the stumps of trees in the woods during the spring and summer.

Bathing in buttermilk reduces the fever.

Sweet oil applied heals and soothes.

A mild solution of sugar of lead kills the poison and prevents spreading.

Knocked "Senseless."—When a person is knocked senseless it is only a form of fainting, and should be treated in much the same way as an ordinary faint. Lay the person on his back, put something under the shoulders to lower the head that the blood may flow back to the brain, sprinkle cold water on the face.

Unless recovery is prompt and thorough, the person should be seen by a physician, even after recovery, as injuries to skull or brain may not reveal themselves until some hours later.

Hiccoughs.—A single inspiration of the breath caused by a sudden contraction of the diaphragm causes hiccoughs. They may usually be cured by drinking a glass of water. If this is not effective a surprise or shock will often stop them.

Holding the tongue will often stop a severe case.

Choking.—First try slapping the back vigorously. If that is not effectual lay the child on the floor face downward and continue slapping the back, being sure that the head is a little lower than the rest of the body. If still obstinate take the child by the heels and hold head downward and let some one pound him on the back until the cause of the choking is removed.

Sprains.—When one says that a wrist or an ankle is sprained he means that the ligaments which bind the bones together have been wrenched or torn. Sprains are very often much more serious than broken bones, and much care must be taken that they do not result in stiffness. The sprained joint should at once be put into very hot water and this water should be kept very warm for some time.

Absolute rest is then required. Careful rubbing of the sprained joint often shortens the time needed for recovery and very often prevents stiffness.

Dislocation.—When the bone of a joint is forced out of place the ligaments are torn and the muscles are apt to be stretched and irritated, and we say the bone is out of joint. A physician must attend to putting the joint back in place, but meanwhile the patient should be kept as quiet as possible. It is well to bind the injured member close to the body, if the injury is of the shoulder or arm; or to tie together the thighs, knees and ankles, if the injury is of the lower extremity.

Broken Bones.—The two ends of the broken bone should be brought together as soon as possible. The doctor should be called at once, but in case the patient has to be carried a long distance the ends of the bone might injure the flesh. It is best to bind the limb close against the body if the injury is of the arm; or to tie together the thighs, knees and ankles, if the injury is of the leg.

Drowning.—When a person is taken out of the water in an apparently drowned condition, there must be no loss of time in attempting to restore breathing. The most practical method of artificial respiration is the one devised by Professor Schaefer, of Edinburgh University. The procedure is as follows:

1. Turn the patient on his face. Loosen clothing that may hinder breathing movements of the chest. Wipe out quickly, but as thoroughly as possible, all froth and dirt that may be in the mouth and throat. Force mouth open and pull tongue forward if necessary.

2. Turn patient's face to his right and rest his head upon his bent left arm so that mouth and nostrils are free for air entrance.

3. Then kneel astride, or on one side of the patient's body, facing his head. Place your hands spread out on the small of his back with the thumbs parallel and close together pointing toward the patient's head, spread the fingers out on each side of the body over the lowest ribs, then lean forward and keeping the arms straight allow the weight of your body to come on to your hands and so to produce a slow steady pressure upon the patient's ribs. The object

of this is to press the ribs downward and inward so as to *decrease* the size of the chest cavity. By this means the air and water, if there be any, are driven out of the patient's air passages. Then swing backward so as to relieve the pressure on the patient's body, but still keep your hands in place; the object being to allow the ribs to spring back and thus *increase* the size of the chest cavity. Repeat this forward and backward movement, pressure and relaxation of pressure, every four or five seconds. In other words, sway your body regularly forward and backward as described twelve or fifteen times a minute without any marked pause between the movements.

Continue this procedure until natural breathing is resumed. There may be no success for a long period; but breathing has been restored by this method when the patient had been breathless as long as two hours.

If help is available, hot flannels may be applied to the limbs and body and friction to the hands and feet for the promotion of warmth; but on no account should the regular effort to restore breathing be interrupted nor should any attempt be made to give restoratives by the mouth until natural breathing has been established and you have tested very carefully the ability of the patient to swallow.

When the patient begins to breathe, he may be turned on his back and further treatment for promotion of warmth and circulation may be adopted. He should be wrapped in warm blankets or coats, and everything done to restore heat; hot flannels over the abdomen, hot water bottles or any hot objects, properly protected, in the arm pits, at the soles of the feet and so on.

When the patient has regained consciousness and is breathing regularly a teaspoonful of warm water may be given carefully to see if he can swallow. If the power of swallowing has returned, a small quantity of *hot black coffee, beef tea,* or *warm brandy and water* may be given. The patient should be gotten to bed as soon as possible and encouraged to sleep. He should be watched very carefully for some time to see that breathing does not fail.

The advantages of this method of artificial respiration over the older ones are:

1. The ease with which artificial respiration may be performed, hardly any exertion being required.

2. The efficiency with which the exchange of air in the lungs can be produced.

3. The extreme simplicity of the procedure.

4. The impossibility of the air-passages being blocked by the falling back of the tongue.

5. The readiness with which water and mucus are expelled from the air-passages through the mouth and nostrils.

6. It involves no risk of injury to the congested or to any other organ.

7. It is very easily remembered, and can be put into operation by one person.

Sunstroke.—1. Lay the person in a shady place.

2. Loosen the clothing.

3. Reduce the heat of the body at once by application of cold water and ice.

4. Send for the doctor at once.

5. Give no medicine or stimulants, as the body is already overheated.

Warning-signs of heat prostration are sick stomach, faintness, dizziness; perspiration ceases and skin becomes dry and hot.

Sunstrokes and heat prostrations may be avoided by following these rules:

1. Keep the general health good.
2. Avoid excesses in eating, drinking, exercise.
3. Avoid use of liquors.
4. Dress according to the season
5. Drink plenty of cool water.
6. Take plenty of sleep in a well-ventilated room.
7. Avoid constipation.

Clothing on Fire.—Wrap patient in a blanket, rug, cloak or shawl to smother the flames. Roll him and slap the burning parts to put out the flame, and then throw on water.

Smothering the flames is the best way to put out any small fire.

Fainting.—The fainting person should be laid with head lower than body. Secure fresh air and keep away bystanders. Give a

teaspoonful of aromatic spirits of ammonia in a little cold water, and allow patient to smell the bottle.

Electric Shock.—A patient rendered unconscious calls for artificial respiration, as after drowning, but it should be continued longer before giving up.

APPENDIX

Dry Measures. The dry measures should be made of metal, or of well-varnished wood with a metal band around the top, or of similar and suitable material. They should preferably be cylindrical. If they are conical, the top diameter should exceed the bottom diameter by an amount not exceeding 10 per cent of the latter.

The diameters should in no case be less than those given below:

Measure.	Minimum Diameters. Inches.
½ bushel..........	13¾
1 peck...........	10⅞
½ peck...........	8½
2 quarts..........	6⅝
1 quart..........	5⅜
1 pint............	4

Length Measures.—The yard measure should be made of well-dried wood with metal ends, or entirely of metal, or of other material of which the form and dimensions remain reasonably permanent under normal conditions. It should be subdivided into inches and their fractions, and also into the customary fractional subdivisions of the yard, i.e., halves, quarters, eighths, and sixteenths.

The tape should be of steel, or of wire-woven cloth when such construction gives it sufficient strength and permanency. At least 1 yard of this tape should be subdivided as above.

2. Equivalents of Capacity Units Used in the Kitchen. The measures of capacity used in the kitchen are based upon the standard cup, as follows:

3 teaspoonfuls	=	1 tablespoonful = 4 drams
4 tablespoonfuls	=	¼ cupful = 2 fluid ounces
½ cupful	=	1 gill = 4 fluid ounces
2 gills	=	1 cupful = 8 fluid ounces
1 cupful	=	8 fluid ounces
2 cupfuls	=	16 fluid ounces
16 fluid ounces	=	1 pint
4 cupfuls	=	1 quart

In the above table all measures are level full. The equivalents given will permit the use of the large glass graduate for measuring liquids in cooking.

EQUIVALENTS OF THE COMMON CAPACITY UNITS USED IN THE KITCHEN

Units.	Fluid Drams.	Tea-spoon-fuls.	Table-spoon-fuls.	Fluid Ounces.	$\frac{1}{4}$ Cup-fuls.	Gills ($\frac{1}{2}$ Cup-fuls.	Cup-fuls.	Liquid Pints.	Liquid Quarts.	Cubic Centi-meters.	Liters.
1 fluid dram equals...........	1	$\frac{3}{4}$	$\frac{1}{4}$	$\frac{1}{8}$	$\frac{1}{16}$	$\frac{1}{32}$	$\frac{1}{64}$	$\frac{1}{128}$	$\frac{1}{256}$	3.7	0.004
1 teaspoonful equals..........	$1\frac{1}{3}$	1	$\frac{1}{3}$	$\frac{1}{6}$	$\frac{1}{12}$	$\frac{1}{24}$	$\frac{1}{48}$	$\frac{1}{96}$	$\frac{1}{192}$	4.9	0.005
1 tablespoonful equals.........	4	3	1	$\frac{1}{2}$	$\frac{1}{4}$	$\frac{1}{8}$	$\frac{1}{16}$	$\frac{1}{32}$	$\frac{1}{64}$	15	0.015
1 fluid ounce equals...........	8	6	2	1	$\frac{1}{2}$	$\frac{1}{4}$	$\frac{1}{8}$	$\frac{1}{16}$	$\frac{1}{32}$	30	0.030
$\frac{1}{4}$ cupful equals...............	16	12	4	2	1	$\frac{1}{2}$	$\frac{1}{4}$	$\frac{1}{8}$	$\frac{1}{16}$	59	0.059
1 gill ($\frac{1}{2}$ cupful) equals........	32	24	8	4	2	1	$\frac{1}{2}$	$\frac{1}{4}$	$\frac{1}{8}$	118	0.118
1 cupful equals...............	64	48	16	8	4	2	1	$\frac{1}{2}$	$\frac{1}{4}$	237	0.237
1 liquid pint equals...........	128	96	32	16	8	4	2	1	$\frac{1}{2}$	473	0.473
1 liquid quart equals..........	256	192	64	32	16	8	4	2	1	946	0.946
1 cubic centimeter equals......	0.27	0.20	0.068	0.034	0.017	0.0084	0.0042	0.0021	0.0011	1	$\frac{1}{1000}$
1 liter equals.................	270	203	67.6	33.8	16.9	8.45	4.23	2.11	1.06	1000	1

TABLES OF WEIGHTS AND MEASURES

Apothecaries' Fluid Measure

60 minims = 1 fluid dram
8 fluid drams = 1 fluid ounce
16 fluid ounces = 1 liquid pint
8 liquid pints = 1 gallon
(British measures differ from above)

Apothecaries' Weight

20 grains = 1 scruple
3 scruples = 1 dram
8 drams = 1 ounce
12 ounces = 1 pound

Avoirdupois Weight

$27\frac{11}{32}$ grains = 1 dram
16 drams = 1 ounce
16 ounces = 1 pound
25 pounds = 1 short quarter
28 pounds = 1 long quarter
4 quarters = 1 hundredweight { short hundredweight = 100 pounds; long hundredweight = 112 pounds }
20 hundredweight = 1 ton { short ton = 2000 pounds; long ton = 2240 pounds }

Circular Measure

60 seconds = 1 minute
60 minutes = 1 degree
90 degrees = 1 quadrant
4 quadrants = 1 circle or circumference

Cubic Measure

1728 cubic inches = 1 cubic foot
27 cubic feet = 1 cubic yard
144 cubic inches = 1 board foot
128 cubic feet = 1 cord

Dry Measure

2 pints = 1 quart
8 quarts = 1 peck
4 pecks = 1 bushel
1 barrel (for fruit, vegetables, and other dry commodities) = 7056 cubic inches = 105 dry quarts

Linear Measure

12 inches	= 1 foot
3 feet	= 1 yard
$5\frac{1}{2}$ yards	= 1 rod or pole
40 rods	= 1 furlong
8 furlongs	= 1 statute mile (1760 yards, or 5280 feet)
3 miles	= 1 league

Linear Measures (Special)

1000 mils	= 1 inch
72 points	= 1 inch
3 barleycorns	= 1 inch
4 inches	= 1 hand
7.92 inches	= 1 surveyor's link
9 inches	= 1 span
6 feet	= 1 fathom
40 yards	= 1 bolt (cloth)
10 chains	= 1 furlong
6080.20 feet	= 1 nautical mile = 1.1516 statute miles

Liquid Measure

4 gills	= 1 pint
2 pints	= 1 quart
4 quarts	= 1 gallon
$31\frac{1}{2}$ gallons	= 1 barrel
2 barrels	= 1 hogshead

Paper Measure

For small papers the old measure is still in use:

24 sheets	= 1 quire
20 quires	= 1 ream (480 sheets)

For papers put up in cases, bundles, or frames the following measure is now used:

25 sheets	= 1 quire
20 quires	= 1 standard ream (500 sheets)

Square Measure

144 square inches	= 1 square foot
9 square feet	= 1 square yard
$30\frac{1}{4}$ square yards	= 1 square rod or perc
160 square rods	= 1 acre
640 acres	= 1 square mile
36 square miles	= 1 township (6 miles square)

Surveyor's Measure

7.92 inches	= 1 link (Gunther's or surveyor's)
100 links	= 1 chain (= 66 feet)
80 chains	= 1 mile

Surveyor's Area Measure

625 square links	= 1 (square) pole or square rod
16 (square) poles	= 1 square chain (surveyor's)
10 square chains or 160 square rods	= 1 acre
640 acres	= 1 square mile
36 square miles	= 1 township

Time Measure

60 seconds	= 1 minute
60 minutes	= 1 hour
24 hours	= 1 day
7 days	= 1 week
365 days	= 1 year
366 days	= 1 leap year

Troy Weight

24 grains	= 1 pennyweight
20 pennyweights	= 1 ounce
12 ounces	= 1 pound (troy)
1000 troy grams	= 1 pound—avoirdupois
1 troy or apothecaries' pound	= 5760 grams

Carat (for precious stones) = 200 milligrams. The carat was formerly an ambiguous term having many values in various countries.

Karat (fineness of gold) = $\frac{1}{24}$ (by weight) gold. For example, 24 karats fine = pure gold; 18 karats fine = $\frac{18}{24}$ pure gold.

Mariner's Measure

6 feet	= 1 fathom
120 fathoms	= 1 cable length
7½ cable lengths	= 1 mile
5280 feet	= 1 statute mile
6085 feet	= 1 nautical mile

Miscellaneous

3 inches	= 1 palm
4 inches	= 1 hand
6 inches	= 1 span
18 inches	= 1 cubit
21.8 inches	= 1 Bible cubit
2½ feet	= 1 military pace

International Metric System.—In the international metric system the fundamental unit is the meter—the unit of length. From this the units of capacity (liter) and of weight (gram) were derived. All other units are the decimal subdivisions or multiples of these. These three units are simply related e.g., for all practical purposes 1 cubic decimeter equals 1 liter and 1 liter of water weighs 1 kilogram. The metric tables are formed by combining the words " meter," " gram," and " liter " with the six numerical prefixes, as in the following tables:

Prefixes.		Meaning.			Units.
milli-	=	one thousandth	$\frac{1}{1000}$	0.001	" meter " for length
centi-	=	one hundredth	$\frac{1}{100}$	.01	
deci-	=	one tenth	$\frac{1}{10}$	.1	
Unit	=	one		1	" gram " for weight or mass
deka-	=	ten		10	
hecto-	=	one hundred		100	
					" liter " * for capacity
kilo-	=	one thousand		1000	

* One meter = 39.37 inches; 1 liter = 1.0567 liquid quarts; 1 gram = 0.035 avoirdupois ounce.

Units of Length.		Units of Capacity.		Units of Weight (or Mass).	
millimeter =	0.001 meter	milliliter =	0.001 liter	milligram =	0.001 gram
centimeter =	.01 "	centiliter =	.01 "	centigram =	.01 "
decimeter =	.1 "	deciliter =	.1 "	decigram =	.1 "
METER =	1 "	LITER =	1 "	GRAM =	1 "
dekameter =	10 "	dekaliter =	10 "	dekagram =	10 "
hectometer =	100 "	hectoliter =	100 "	hectogram =	100 "
kilometer =	1000 "	kiloliter =	1000 "	kilogram =	1000 "

Units of Area. The table of areas is formed by squaring the length measures, as in our common system. For land measure 10 meters square is called an " *are* " (meaning " area "). The side of one are is about 33 feet. The hectare is 100 meters square, and, as its name indicates, is 100 ares, or about 2½ acres.

Relative Value.	Length.	Surface.	Capacity.	Solidity.	Weight.
10,000	Myriameter				
1,000	Kilometer...	....	Kiloliter...	....	Kilogram
100	Hectometer.	Hectare ..	Hectoliter..	....	Hectogram
10	Dekameter .	....	Dekaliter .	Dekastere..	Dekagram
Unit	Meter	Are	Liter	Stere......	Gram
0.1	Decimeter ..	Deciare...	Deciliter...	Decistere ..	Decigram
0.01	Centimeter..	Centiare .	Centiliter..	....	Centigram
0.001	Millimeter..	....	Milliliter...	....	Milligram

APPROXIMATE EQUIVALENTS OF THE FRENCH (METRIC) AND ENGLISH MEASURES

1 yard	$\frac{11}{12}$ meter.
11 meters	12 yards.
To convert meters into yards	Add $\frac{1}{11}$th.
1 meter = 1.1 yd.; 3.3 ft.	3 ft. $3\frac{3}{8}$ inches ($\frac{1}{512}$ less). 40 inches (1.6 per cent less).
1 meter, by the Stand. Commission.	= 39.38203 inches.
1 meter, by the Act of 1878	= 39.37079 inches.
1 foot	3 decimeters (more exactly 3.048).
1 inch	25 millimeters (more exactly 25.4).
1 mile	1.6 or $1\frac{3}{5}$ kilometers (more exactly 1.60931).
1 kilometer	$\frac{5}{8}$ of a mile.
1 chain (22 yards)	20 meters (more exactly 20.1165).
5 furlongs (1100 yards)	1 kilometer (more exactly 1.0058).
1 square yard	$\frac{6}{7}$ square meter (more exactly .8361).
1 square meter	$10\frac{3}{4}$ square feet. $1\frac{1}{5}$ square yards.
1 square inch	$6\frac{1}{2}$ square centimeters (more exactly 6.45).
1 square mile (640 acres)	260 hectares (0.4 per cent less).
1 acre (4840 square yards)	4000 square meters (1.2 per cent more).
1 cubic yard	$\frac{3}{4}$ cubic meter (2 per cent more).
1 cubic meter	$1\frac{1}{3}$ cubic yards ($1\frac{2}{3}$ per cent less).
1 cubic meter	$35\frac{1}{3}$ cubic feet (.05 per cent less).
1 cubic meter of water	1 long ton nearly.
1 kilogram	2.2 pounds fully.
1000 kilograms 1 metric ton	1 long ton nearly.
1 long hundredweight	51 kilograms nearly.
1 United States hundredweight	$45\frac{1}{2}$ kilograms nearly.

OBJECTS VISIBLE AT SEA LEVEL IN CLEAR WEATHER

The following table shows the distance at sea level at which objects are visible at certain elevations:

Feet.	Miles.	Feet.	Miles.	Feet.	Miles.	Feet.	Miles.
1	1.31	10	4.18	40	8.37	80	11.83
5	2.96	20	5.92	45	8.87	90	12.25
6	3.24	25	6.61	50	9.35	100	13.23
7	3.49	30	7.25	60	10.25	150	16.22
8	3.73	35	7.83	70	11.07	200	18.72

METRIC MEASURES

Measures.	Metric to Customary.			Customary to Metric.		
LENGTHS	1 millimeter	= 0.03937	inch	1 inch	=25.4001	millimeters
	1 centimeter	= 0.3937	inch	1 inch	= 2.54001	centimeters
	1 meter	= 39.37	inches	1 inch	= 0.0254	meter
	1 meter	= 3.28083	feet	1 foot	= 0.304801	meter
	1 meter	= 1.093611	yards	1 yard	= 0.914402	meter
	1 kilometer	= 0.62137	mile	1 mile	= 1.60935	kilometers
AREAS	1 square millimeter	= 0.00155	square inch	1 square inch	=645.16	square millimeters
	1 square centimeter	= 0.1550	square inch	1 square inch	= 6.452	square centimeters
	1 square meter	=10.764	square feet	1 square foot	= 0.0929	square meter
	1 square meter	= 1.1960	square yards	1 square yard	= 0.8361	square meter
	1 square kilometer	= 0.3861	square mile	1 square mile	= 2.5900	square kilometers
	1 hectare	= 2.471	acres	1 acre	= 0.4047	hectare
VOLUMES	1 cubic millimeter	= 0.000061	cubic inch	1 cubic inch	= 16,387.2	cubic millimeters
	1 cubic centimeter	= 0.0610	cubic inch	1 cubic inch	= 16.3872	cubic centimeters
	1 cubic meter	=35.314	cubic feet	1 cubic foot	= 0.02832	cubic meter
	1 cubic meter	= 1.3079	cubic yards	1 cubic yard	= 0.7645	cubic meter
CAPACITY . . . *Liquid*	1 liter	= 1.05668	quarts	1 quart	= 0.94636	liter
	1 liter	= 0.26417	gallon	1 gallon	= 3.78543	liters
Dry	1 liter	= 0.9081	quart	1 quart	= 1.1012	liters
	1 liter	= 0.11351	peck	1 peck	= 8.80982	liters
	1 dekaliter	= 1.1351	pecks	1 peck	= 0.8810	dekaliter
	1 hectoliter	= 2.83774	bushels	1 bushel	= 0.35239	hectoliter
MASSES . . . *Avoirdupois*	1 gram	=15.4324	grains	1 grain	= 0.6480	gram
	1 gram	= 0.03527	ounce	1 ounce	= 28.3495	grams
	1 kilogram	= 2.20462	pounds	1 pound	= 0.45359	kilogram
Troy	1 gram	= 0.03215	ounce	1 ounce	= 31.10348	grams
	1 kilogram	= 2.67923	pounds	1 pound	= 0.37324	kilogram
Apothecaries'	1 gram	= 0.2705	dram	1 dram	= 3.6967	grams
	1 gram	= 0.8115	scruple	1 scruple	= 1.2322	grams

Familiar Facts

To find circumference of a circle multiply diameter by 3.1416.
To find diameter of a circle multiply circumference by .31831.
To find area of a circle multiply square of diameter by .7854.
To find area of a triangle multiply base by one-half perpendicular height.
To find surface of a ball multiply square of diameter by 3.1416.
To find solidity of a sphere multiply cube of diameter by .5236.
What is an " equal square "? Is not its " diameter " the same as a side?
To find cubic inches in a ball multiply cube of diameter by .5236.
Doubling the diameter of a pipe increases its capacity four times.

A gallon of water (U. S. standard) weighs 8 pounds ⅓ ounce, and contains 231 cubic inches.

A cubic foot of water contains 7½ gallons, 1728 cubic inches, and weighs 62½ pounds.

To find the pressure in pounds per square inch of a column of water multiply the height of the column in feet by .434.

Steam rising from water at its boiling point (212 degrees) has a pressure equal to the atmosphere (14.7 pounds to the square inch).

WEIGHT OF EVERYDAY THINGS

A barrel of flour weighs	196 pounds
A barrel of salt weighs	280 pounds
A barrel of beef weighs	200 pounds
A barrel of pork weighs	200 pounds
A barrel of fish weighs	200 pounds
A keg of powder equals	25 pounds
A stone of lead or iron equals	14 pounds
A pig of lead or iron equals	21½ stone
Anthracite coal, broken—cubic foot averages	54 pounds
A ton loose occupies	40–43 cubic feet
Bituminous coal, broken—foot averages	49 pounds
A ton loose occupies	40–48 cubic feet
Cement hydraulic Rosedale, weight per bushel	70 lbs.
Cement hydraulic Louisville, weight per bushel	62 pounds
Cement hydraulic Portland, weight per bushel	96 pounds
Gypsum, ground, weight per bushel	70 pounds
Lime, loose, weight per bushel	70 pounds
Lime, well shaken, weight per bushel	80 pounds
Sand at 98 pounds per cubic foot per bushel	122½ pounds

18.29 bushels equal a ton. 1.181 tons, cubic yard.

CONVERSION TABLE

To Change	To	Multiply By
Inches	Centimeters	2.5400
Centimeters	Inches	0.3937
Feet	Meters	0.3048
Meters	Feet	3.2808
Miles	Kilometers	1.6093
Kilometers	Miles	0.6213
Square inches	Square centimeters	6.4520
Square centimeters	Square inches	0.1550
Square feet	Square meters	0.0929
Square meters	Square feet	10.7640
Square yards	Square meters	0.8361
Square meters	Square yards	1.1960
Square miles	Square kilometers	2.5900
Square kilometers	Square miles	0.3861
Cubic inches	Cubic centimeters	16.3872
Cubic centimeters	Cubic inches	0.0610
Cubic yards	Cubic meters	0.7645
Cubic meters	Cubic yards	1.3079
Cubic feet	Liters	28.3170
Liters	Cubic feet	0.0353
Quarts	Liters	0.9463
Liters	Quarts	1.0566
Fluid ounces	Cubic centimeters	29.5740
Cubic centimeters	Fluid ounces	0.0338
Ounces	Grams	28.3495
Grams	Ounces	0.0352
Pounds	Kilograms	0.4535
Kilograms	Pounds	2.2046
Grains	Grams	0.0648
Grams	Grains	15.4324
Pounds weight	Dynes	444520.5800
Dynes	Pounds weight	22496×10^{-10}
Foot pounds	Kilogrammeters	0.1382
Kilogrammeters	Foot pounds	7.2330

PREPARATIONS OF SOLUTIONS

Ammonium Molybdate.—Dissolve $7\frac{1}{2}$ gm. of ammonium molybdate in 50 cu. cm. of water. Add a little water if necessary. Pour the mixture, with constant stirring, into a mixture of 25 cu. cm. of concentrated nitric acid and 25 cu. cm. of water. Allow it to stand for several days.

Barium Chloride.—Dissolve 1 oz. (28 grams) of barium chloride in 200 cu. cm. of water.

Fehling's Solution.—Dissolve 7 gms. of crystallized sulphate of copper in 100 cu. cm. of water for **solution A.**

Dissolve 34.6 grams of Rochelle salts in 45 cu. cm. of water and 25 grams of caustic soda in 40 cu. cm. of water. Mix. Add enough water to make 100 cu. cm. for **solution B.**

When ready to use mix equal parts of A and B.

Iodine.—Agitate 2 grams of crystal iodine with a solution of 6 grams of potassium iodide in a little water. When the iodine is dissolved, add enough water to make 100 cu. cm. of the solution.

Phenolphthalein.—Dissolve $\frac{1}{10}$ gram in 100 cu. cm. of alcohol.

Sodium Hydroxide.—Dissolve 20 grams of caustic soda in 100 cu. cm. of water.

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